

JANUARY 7, 1960

MACHINE

DESIGN

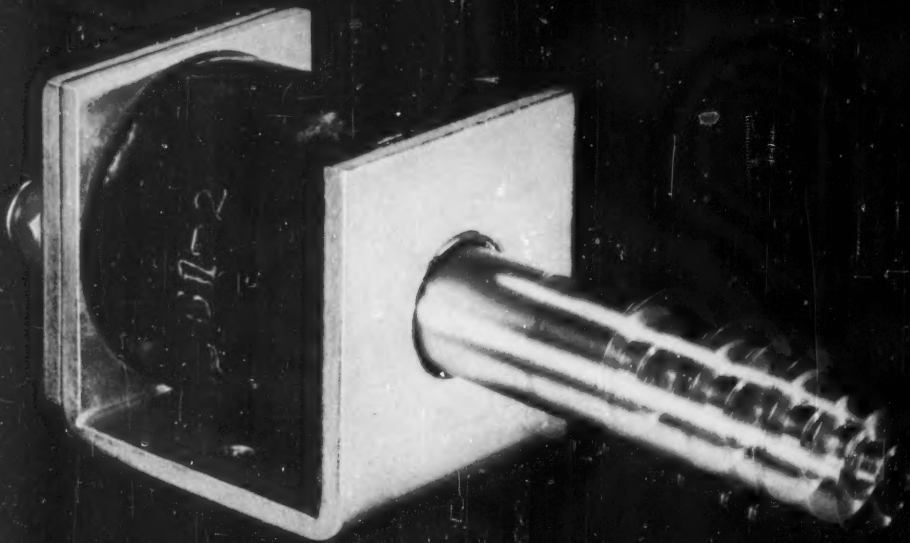
A PENTON PUBLICATION — BIWEEKLY



Planetary Gear Trains

Contents, Page 3

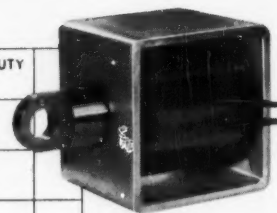
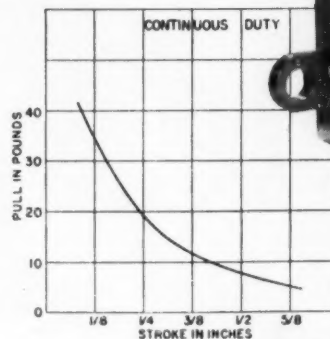
100 MILLION OPERATIONS!



new ASCO solenoid has virtually unlimited life!

This is ASCO's new long-life solenoid. Unlike ordinary solenoids where plunger rides loosely in the sleeve this device is precision manufactured to tolerances of $\pm .0005"$. A rugged machine tool bearing guides plunger to provide accurate, smooth stroking. There is virtually no wear—almost unlimited solenoid life.

If your application calls for a precision solenoid that must operate consistently and indefinitely, investigate this new long-life ASCO design. ASCO solenoids are available to meet a wide variety of applications. For additional information contact your ASCO engineer or write for Catalog 57-S5.



DC pull type solenoid, continuous duty—125 volts. Curve is based on vertical operation against gravity.

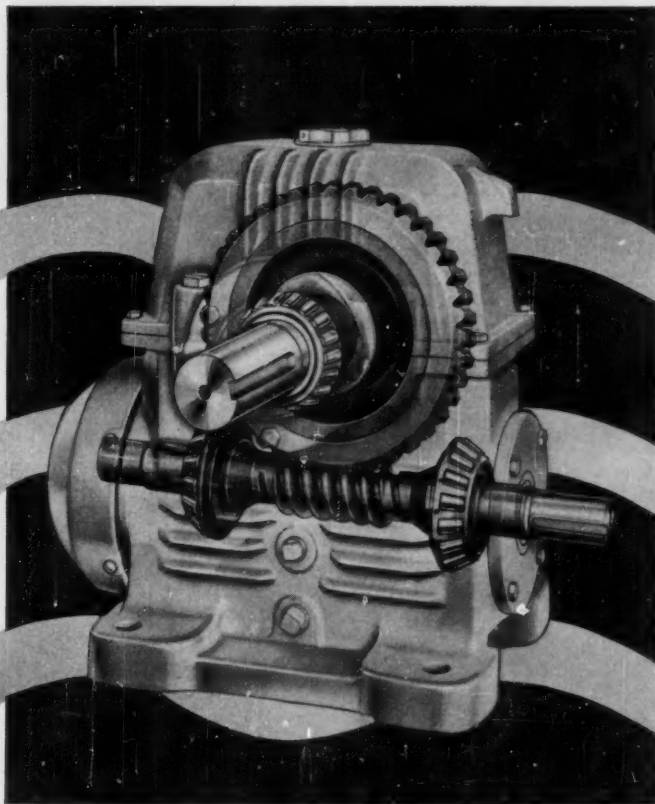
ASCO Electromagnetic Control

Automatic Switch Co. 54-A HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600
AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

ASCO

NEW LINK-BELT FAN-COOLED WORM GEAR SPEED REDUCERS

THREE BASIC TYPES . . .
WITH MANY VARIATIONS



most complete line in industry

Industry's most complete line of worm gear speed reducers introduces more advanced refinements for reducing high motor speeds to requirements of modern production machines. Types and sizes for every right-angle need . . . single or double reduction . . . horizontal or vertical mountings . . . ratios from 5:1 to 3600:1, torque ratings up to 135,000 pound inches, up to 150 horsepower.

Compact, self-lubricated and fan-cooled, these units operate smoothly and quietly under high input speeds. Power is transmitted at either moderate or slow output speeds, with ample capacity

for heavy loads. This all adds up to high ratings, maximum heat dissipation and minimum maintenance.

For complete information call your nearby Link-Belt office. Ask for Book 2824.

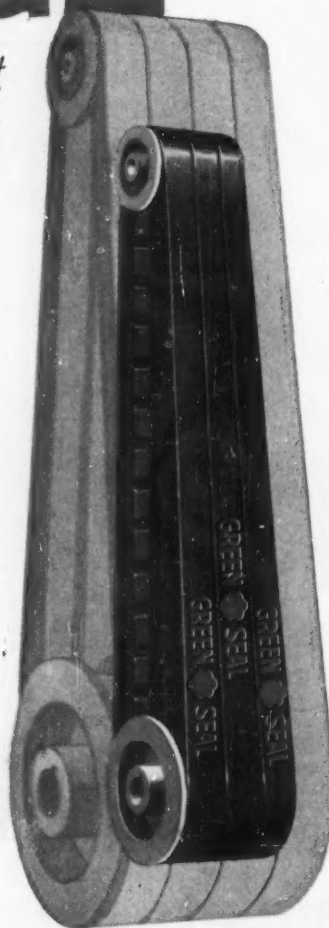
LINK-BELT
SPEED REDUCERS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

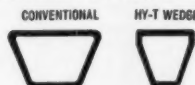
NEW OPENING WEDGE IN YOUR COST-CUTTING CAMPAIGN:

HY-T WEDGE

*—a new kind of V-Belt
so powerful
yet so compact
it can cut
your drive costs
up to 20%*



Your V-Belt drive costs have to shrink
— with Goodyear quality wedge-type
V-Belts like these now at your disposal.



First place, the completely "fat-free" design and rugged construction of a HY-T WEDGE means you can use fewer belts — on smaller sheaves — with shorter centers — to handle any V-Belt job.



You cash in on famed Green Seal quality. Sinewed with exclusive 3-T Cord, every set of these rugged belts will remain a perfectly matched set even through long storage. On the drive, they outlast anything else you can use.



In the larger sizes, the HY-T WEDGE offers rugged, multiple-ply construction. And smaller sizes are notched — another Goodyear feature — for cool-running flexibility over small pulleys.



Still another Goodyear "plus" — every one of the 46 HY-T WEDGE V-Belts is oil-resistant and static conducting. And you don't pay one cent extra for this extra protection.

And remember — these great, new HY-T WEDGE V-Belts are a development of Goodyear — pioneer of the original "wedge" design more than 10 years ago. They incorporate all the advances Goodyear has uncovered in turning out thousands of specialized "wedge" belts for specialized purposes.

For the complete story, check with the G. T. M. — Goodyear Technical Man — through your Goodyear Distributor. Or write Goodyear, Industrial Products Division, Lincoln 2, Neb., or Akron 16, Ohio.

HY-T WEDGE with the
GREEN SEAL BY

GOOD YEAR

HY-T WEDGE, Green Seal — T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio THE GREATEST NAME IN RUBBER



Front Cover: Stripped of all but the essentials, George Farnsworth's drawing of a planetary gear train highlights William H. Wilkinson's article on Page 155. The small sketch is a velocity diagram—one of the four analysis methods discussed in the article.

January 7, 1960

The Engineer: Paragon or Paradox? 25

EUGENE RAUDSEPP—Part 3: *His Interests*—What's the engineer really like? Here's the picture psychologists have formed from tests to determine his likes and dislikes.

The Product Design Review Committee 112

A. M. THOMAS—How to eliminate or minimize problems in product development by using a team of engineering specialists to review design efforts at critical stages.

Positioning by Single Rotation 116

CHARLES E. BALLEISEN—A simplified method for finding basic geometrical relationships in the design of parts which move from one place to another.

Malleable Iron—Fatigue and Impact Effects 124

Results of recent investigations to determine the behavior of malleable-iron castings under dynamic loads that are either cyclic or suddenly applied.

Continuous Cam Curves 127

EDGAR SCHMIDT—How to develop cam profiles that produce continuous displacement and keep acceleration forces to a minimum without sudden changes in magnitude.

Self-Optimizing Servo Circuits 139

J. M. NIGHTINGALE—A new design concept for controlling control-systems by closed-loop, negative feedback circuits with balanced accuracy and stability characteristics.

Thermal Expansion of Elastomers 144

JOHN JORDAN—New design data for improved seals of synthetic rubber.

Mobility of Cross-Country Vehicles 145

M. G. BEKKER—Part 2: *Flotation and Motion Resistance*—The general nature of "sinkage," how it is determined, and how its effect on vehicle motion can be analyzed.

Simple Slip Rings 154

J. VALENTICH—*Tips and Techniques*—How to use silver ribbons as temporary slip rings for stress analysis of rotating equipment with strain gages.

Planetary Gear Trains 155

WILLIAM H. WILKINSON—*Data Sheet*—Four ways to calculate planetary-gear relationships: Energy method, graphical method, relative-velocity method, tabular method.

Flush Printed Circuits 161

LEROY N. CHELLIS—*Design Abstracts*—Basic requirements for reliability and long life of flush circuitry and how they are achieved in manufacture.

CONTINUED NEXT PAGE

The G.P. and the Specialists 111

COLIN CARMICHAEL—Editorial

Engineering News 6

Chrysler's 300-F	6	Small-vehicle transaxle	30
ASM year-end report	6	Ultrasonic motion analyzer	32
Lichtenberg patterns	8	Three-pole magnet	32
"Ramrod" lube system	10	Teflon heat shield	34
Tulahoma tunnel	12	Caravelle suspension	36
Wankel engine	14	Potting powder	38
Trends	22		
Meetings and Shows	39		

Scanning the Field for Ideas 120

Magnetic clutching provides accurate stepping motion—hand-operated planetary permits instantaneous power reversal—adjustable inserts control pump clearances—tapped end-wall simplifies removal of split bushing—contact wheels "lock" or "unlock" electrical circuit.

Design in Action 133

Controlled leak stops battery drain in electronic flash circuit—3-D plotter uses transparent stylus to avoid obscuring the plot—rocking differential provides momentary dwell for banding cycle.

Tips and Techniques

Selecting spring proportions	153
--	-----

Design Abstracts 161

New Parts and Materials 176

Engineering Department Equipment 198

The Engineer's Library 202

Noteworthy Patents 204

Backtalk 220

Helpful Literature 168

Subject Index	17	Advertising Index	221
Reader Service Cards	19	Business Staff	221

IN THE NEXT ISSUE: Revising the drafting manual . . . testing at high heat rates . . . Geneva mechanisms . . . design data for Teflon TFE and FEP . . . track and wheel evaluation for cross-country vehicles . . . zero-gradient spring system

Editor

COLIN CARMICHAEL

Associate Managing Editors

BENJAMIN L. HUMMEL
ROBERT L. STEDFELD

Associate Editors

LEO F. SPECTOR
WILLIAM S. MILLER
SPENCER R. GRIFFITH
JAMES A. PARKS
MELVIN E. LONG

Assistant Editors

CLARE E. WISE
THEODORE M. LEACH
STANLEY G. COOK
RICHARD A. JACOBSON
KENNETH J. REHOR
JOHN J. HOSTAK
JANE H. SMITH
MARIAN L. EICHAR

Art Editors

FRANK H. BURGESS
ROBERT L. TUFTS

Contributing Editor

ROGER W. BOLZ

EDITORIAL OFFICES

Penton Building, Cleveland 13, Ohio

Branch Offices

New York, Detroit, Chicago, Pittsburgh, Washington, London



MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, \$10. Single copies \$1.00. Other countries: One year, \$25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday and copyrighted 1960 by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

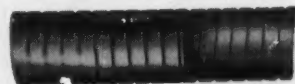
Whatever your problem in flexible hose connections, call the Man from Anaconda Metal Hose



Seamless: Of tin bronze (98¾% copper, 1¼% tin)—also corrugated stainless steel—in sizes ½" through 4" I.D. For conveying fluids, chemicals, etc., under conditions of flexure or vibration and to allow for misalignment. Reusable (mechanical type), soldered or welded fittings.



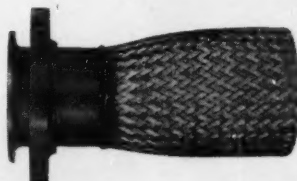
Stripwound: Constructed from brass, bronze, aluminum, galvanized or stainless steel. Sizes ½" through 8" I.D. A rugged type of hose for general service as steam, oil, water, particularly where the hose is handled manually. Fittings: soldered or heat-proof (packed-on).



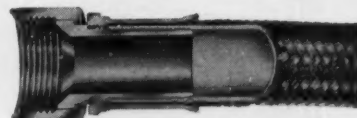
Type UI: Interlocked unpacked hose in galvanized steel, stainless steel, aluminum, etc. Sizes through 8" I.D. For ventilating ducts, dust collection, engine exhausts, exhausts at grinding machines, bottle chutes, drain lines, protective casing for flexible hose assemblies.



Diesel: Heavy-duty steel exhaust and air intake hose. Sizes 2" through 16" I.D. Designed for rugged, heavy-duty use. Helical corrugations with open or closed pitch. Also in stainless steel (type Y-21) for corrosive applications.

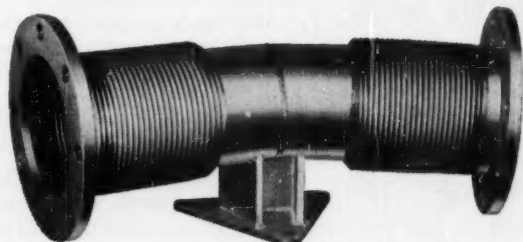


Flexpipe: Takes up travel in piping, connects misaligned ports, dampens noise and vibration in piping. Standard sizes and lengths. Available in bronze, stainless steel, steel; in sizes ¼" through 16" I.D. with NPT fittings, flanges or welding nipples.



Teflon* Anaconda flexible connectors of Teflon with stainless steel wire braid for use with pipe sizes from ⅛" through 1¼". Available in a wide variety of standard hose assemblies complete with fittings.

*Teflon is a DuPont trademark for its fluorocarbon resins.



AX Tubing: Large diameter tubing for big, tough jobs. Available in Type 321 Stainless Steel, and other metals and alloys. Sizes from 4½" through 14" I.D.

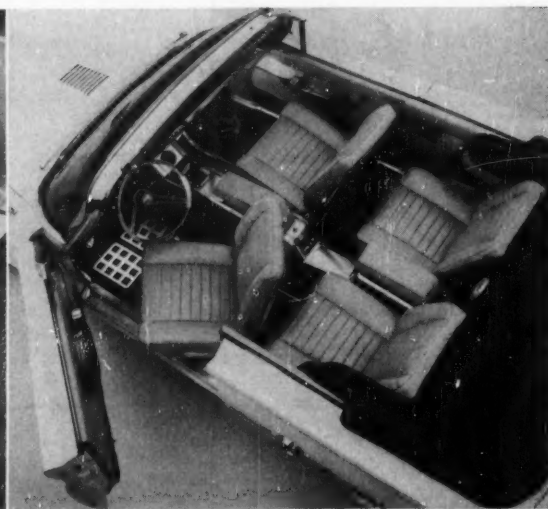
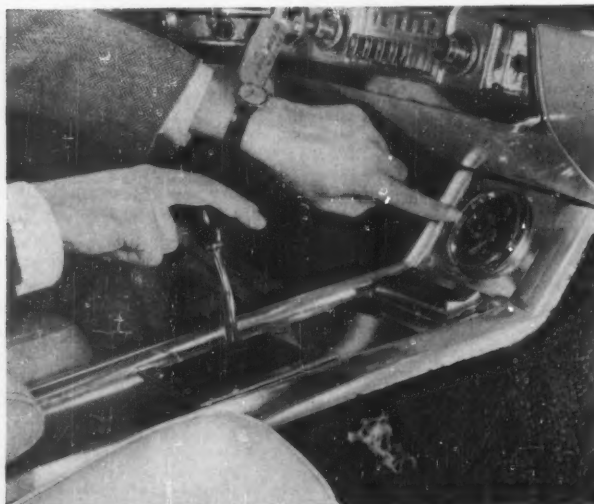
Designed to handle axial and lateral movement—while conveying large volumes of liquids or gases—for bulkhead seals, etc.

FREE TECHNICAL SERVICE. Anaconda Metal Hose specialists are constantly working with design engineers on special flexible connectors and hose to meet new problems. Having broad experience working in stainless steel, other steel alloys, Monel, copper alloys, aluminum, and Teflon, they can save you considerable time and money in designing the flexible connector best suited for any of your jobs.

Our specialists are available to you through Anaconda Metal Hose representatives in leading cities—see listing "Metal Hose" in the Yellow Pages. Or write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn.

ANACONDA[®] METAL HOSE

Stick Shift for the Carriage Trade



The 300-F, most powerful Chrysler ever built, is offered this year with two engine-transmission options: Standard is a 375-hp ram-induction powerplant equipped with a three-speed automatic transmission; optional, for the well-heeled hot rodder, is a 400-hp version of the engine coupled to a French (Point-a-Mousson) manual four-speed gear box. Suspension has been completely modified—springing in front (torsion bars) is 40 per cent stiffer than in standard Chryslers; rear springs (conventional leaves) are 50 per cent stiffer. Interior has also been redone—an instrument-control console (with oversized tachometer) runs the length of the passenger area.



Year-End Report from ASM Lists '59 Metals Gains

NOVELTY, OHIO — Demands for high-temperature metals for space vehicles, better metals for improved products, and cheaper metals to meet competition of other materials resulted in a number of significant metallurgical and metalworking advances during the past year. Some of them are pointed out in a report from Allan Ray Putnam, managing director of the American Society for Metals.

Getting on top of foam

Foamed metals, sought for many years, became a reality in 1959. Foaming makes possible metal shapes weighing as little as one-

tenth that of similar, solid shapes. Earliest uses are in aircraft; future applications are expected in boat hulls, road surfaces, and building panels. So far, most foaming has been done with aluminum, but steel and copper can also be treated in this manner.

Powders and new metals . . .

Steel sheet and strip may be produced commercially from iron powders within five or six years by a method now being developed. Eliminating blast furnaces, open hearths, and other melting equipment, the new process promises to save 40 to 50 per cent of equipment

costs and cut steel costs.

ASM takes exception to the designation "rare earth" for the 15 metals commonly known by that name, since they are neither earth nor rare. Improvements in separating these metals, which are found together as oxides in their natural state, now permit use of several of this group. Yttrium, called one of the most promising, is nearly as light as aluminum and is comparable structurally to titanium. Its added advantage of low nuclear cross section makes yttrium a candidate for nuclear structures.

. . . and dusting off "old" ones

High-nickel alloy, attractive to aerospace industries but previously made only in experimental quan-

... Fluid Power

news

REPORT
NO. 11,300
NEW
LIQUID
LEVEL
CONTROL

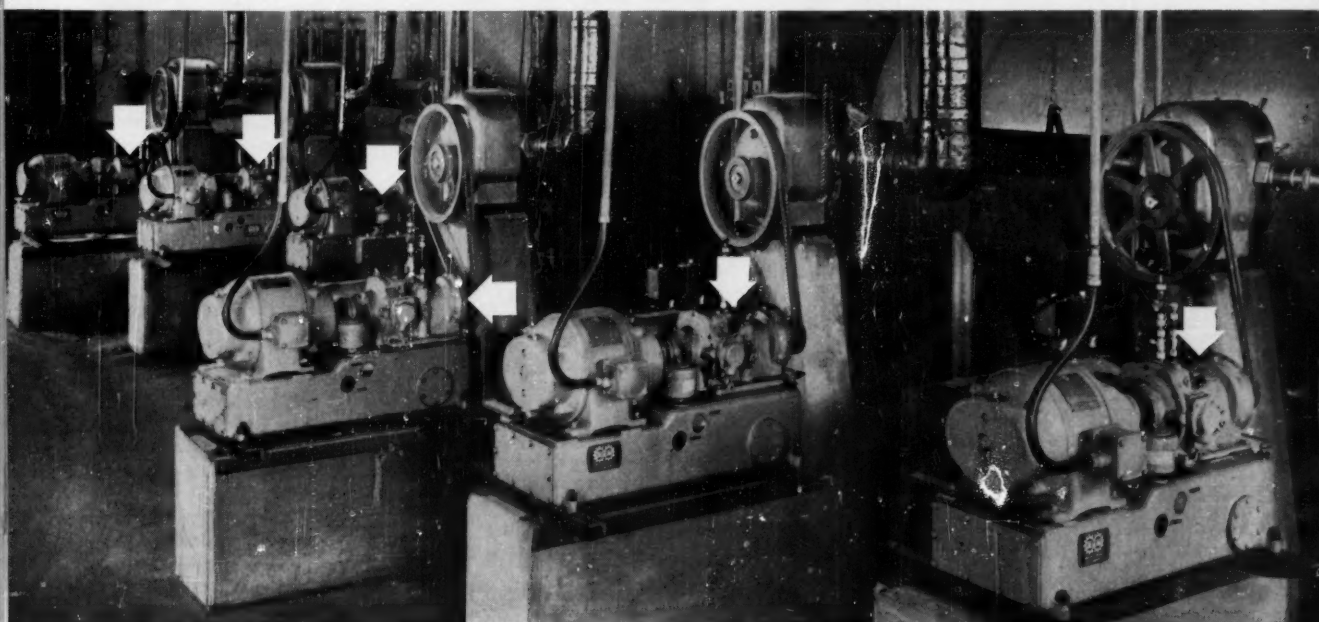
From Oilgear Application-Engineering Files

HOW OILGEAR DRIVE AND CONTROL SYSTEM STABILIZED BEER FILLING LEVEL

CUSTOMER: *Large Western Brewery (Name withheld by request)*

DATA: Highly carbonated beverages must be handled gently. Throttling flow of beer into filling machine reservoirs causes foam and irregularity of liquid height, making accurate filling of cans or bottles difficult. These reservoirs are small compared to the flow through them. Costly losses are incurred on tax-paid cans "in process" due to under or overfilling. Any beer

pump drive-control system must respond immediately, have smooth action, and be unaffected by daily wash-downs required to maintain sanitary operations. Accurate automatic control, dependable operation, and ease of maintenance—as always—are important factors in the selection of this equipment.



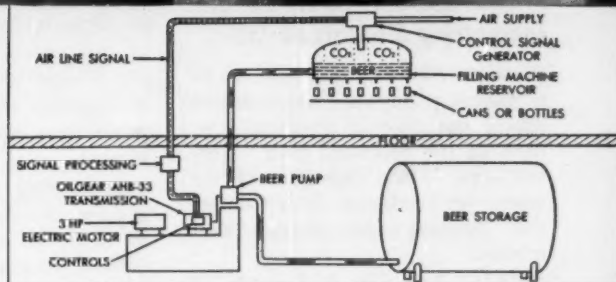
SOLUTION: Shown "on the job" above, are 6 Oilgear AHB-33, two-way, "Any-Speed" transmissions driven by 3 hp electric motors, mounted on standard reservoir bases. Transmissions drive beer pumps through dual "V" belts. Beer is pumped from storage tanks to bottle or can filling machine reservoirs on the floor above. Liquid level in filling reservoirs is controlled automatically by a low pressure CO₂ signal . . . as level rises, pressure rises . . . as level falls, pressure falls. Translated to air pressure signals, which, transmitted to controls on Oilgear transmissions, automatically—instantly increase, decrease, reverse, or stop the beer pumps. Where former throttling system caused foam and irregular levels, this Oilgear system holds reservoir level to $\pm \frac{1}{16}$ " under continuous operation . . . assuring accurate filling of each can or bottle. Beer pumps are flushed under water pressure without disconnecting drives. Several years of continuous service have proven drives to be extremely dependable under all conditions, with little or no attention.

Oilgear Application-Engineering can also provide practical solutions to your linear or rotary drive problems. Call the factory-trained Oilgear application-engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY

Application-Engineered Fluid Power Systems

1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN



Similar Oilgear "Any-Speed" drives have improved performance on can closing, filling; paper, printing, textile, tape, and rubber processing machines; extruders, capstans, winders, stokers, centrifuges, gang-saw feeds, saw mill carriages, conveyors, and the like. They provide efficient conversion of any constant rotary motion to accurately controlled variable rotary motion . . . smooth, stepless, uniform acceleration from zero to maximum in either direction . . . manual, hydraulic, electric or electro-hydraulic controls—providing complete flexibility of location . . . low power consumption—using power only in proportion to work performed . . . durable, trouble-free, low maintenance due to simplicity and automatic lubrication of all rotating parts.

ties, is now commercially available. It can be used at temperatures up to 1800 F; at 1400 F, its yield strength is 120,000 psi. Strength-to-weight ratios are superior to those of other metals at these temperatures.

Humble lead has, in experiments, been endowed with increased strength and high-temperature properties. A boron and lead combination provides shielding material which protects against both gamma rays and neutrons. Mixing certain other metals with lead results in alloys with tensile strengths of 1500 psi—five times that of pure

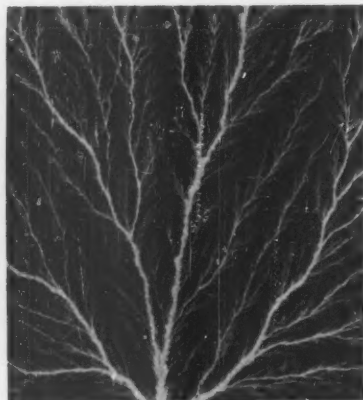
lead.

Beryllium-forming breakthrough, combining powder metallurgy and forging methods, made possible the first major use of this metal in 1959. Beryllium is expected to find continued use in aircraft and missiles, as well as in the nuclear energy field.

Anticorrosion coating

Heavy coatings of aluminum (0.004 in. thick) can now be deposited on steel and other metals by a new vapor coating method. Previously a film of aluminum only about one-millionth of an inch thick could be deposited.

The Lichtenberg Pattern: Key to Dielectric Secrets



Electrets—chilled Lucite plates that are electrically charged by exposure to an electron beam from a Van de Graff generator—are a new subject for research by Beckman & Whitley's R & D Div. By several methods, including impact shock on the edge, they can be made to discharge, leaving the Lichtenberg pattern (left) on the Lucite. There is evidence that the discharge takes place in something under 0.58 microseconds at a velocity of more than 20 million cm per sec. Beckman is interested because of new information that electrets may shed on dielectric breakdown, area-initiation of explosives and energy storage.

Profiles from the Mill: Engineering Students of '59

WASHINGTON—Ten per cent more engineering degrees were earned during the 1958-59 academic year than in the preceding year. Here are some of the highlights of the report by Engineers Joint Council and Scientific Manpower Commission:

- 38,162 B.S., 6761 M.S., and 713 Ph.D. degrees in engineering were earned during academic 1958-59.
- Increases over 1957-58 were 10 per cent in B.S. and Ph.D. degrees, and 16 per cent in M.S. degrees.
- By 1963, industry will want 12 engineers for every 10 sought in 1959, and by 1965, 15 for every 10.
- There is some evidence that freshman enrollment for the fall of 1959 is down.

Another aspect of the survey had to do with the number of women in engineering. Here are some of the findings on the fair sex:

- Less than 1 per cent of freshman engineering classes are made up of women.
- From 1949 to 1958 the number of lady engineers increased from 763 to 1718, as compared to 288,000 male engineers at the end of 1958.
- In the fields of science and mathematics, the ladies seem to be doing much better. Twenty per cent of the junior majors in these fields are women. In the physical sciences, chemistry claimed the greatest number in the sample surveyed—1812 out of 2358 total. Mathematics attracted 3357; biological sciences, 4739. The total number of women students surveyed was 11,274.

Topics

Private earthquakes will be staged by four California Institute of Technology engineers in an attempt to learn how to construct buildings that will withstand natural quakes. An earthquake simulator, bolted to the floor of a chosen building, rotates two unbalanced weights rapidly in opposite directions to produce vibrations which crack the building. Magnitude of the quakes varies according to the weights used and the speed of rotation.

United they roll: A national organization for owners of cars with 110-inch or less wheelbase has been founded. Richard S. Ross, president of the Small Auto Club, 1717 Walnut St., Philadelphia, Pa., says members will exchange information on performance and repairs of their cars, campaign for safe driving, and work for legislation that does not discriminate against owners of small cars.

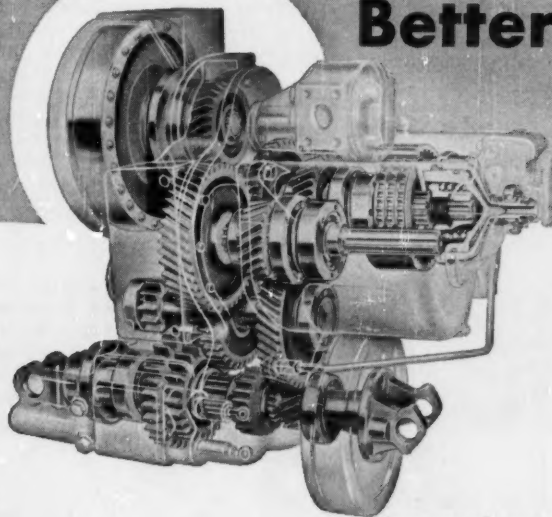
Homework via the telephone, common enough among the high-school population, moves—with refinements—onto the college campus at the University of Michigan. Two major improvements are that the "conversation" is one-sided and instructive. By sitting in a "learning booth" and dialing a device which resembles a telephone, a student can listen to any of a wide variety of foreign-language recordings. Lessons on continuously playing tape recordings last from one minute to an hour.

Window-shopping comfort is provided Chicago browsers by a new heat lamp system in front of display windows at Carson, Pirie, Scott & Co. GE quartz infra-red lamps, like those used to cook hot dogs, toast space vehicles, and bake and dry industrial products, supply enough heat to warm persons standing 6 to 8 feet away from the window. Because the lamps warm any persons or objects which the rays fall upon, they are expected to help keep the sidewalk dry too.

The water of Niagara will go uphill to increase electricity generated at the Falls. There are certain restrictions on diverting water for power generation, but it is available during evening hours. Water will be pumped into a reservoir by reversible pump turbines—turbine generator sets that can be run backwards. New Allis-Chalmers generators will reverse the normal process by feeding spare electric power into the generator and using it as a motor. This spins the turbine backwards and causes it to act as a pump. Water will be released to run downhill and generate power as needed.



Better performance at lower cost



Tractomatic Transmission in Allis-Chalmers TL-14 Tractoloader features Twin Disc Torque Converter

Allis-Chalmers' new TL-14 Tractoloader with Tractomatic Transmission takes the fatigue out of loader operation. A direction control lever on the steering column actuates forward and reverse clutches hydraulically—changes directions without clutching, shifting gears, or stopping the machine. Since reverse speeds are 30% faster than forward, reversing the machine automatically places it in a higher gear, producing a corresponding increase in efficiency. Cycles are faster, production higher.

The Tractomatic Transmission has four speeds in both forward and reverse. It is simpler in design and less expensive than full power transmis-

sions, yet often outperforms them on short haul loading and stockpiling jobs. This is true because, once the proper ratio for a given job has been selected, there is seldom if ever any need for operator to change speeds.

An integral part of the Tractomatic Transmission is a Twin Disc Single-Stage Torque Converter. Besides increasing torque automatically as needed, the converter permits rapid clutch engagement and absorbs the shock of the shift in its whirling fluid.

Allis-Chalmers introduced the first torque converter drive in a crawler tractor 18 years ago. That first unit featured a Twin Disc Converter and the same is true of many present-day Allis-Chalmers construction ma-

chines. For the optional Tractomatic Transmission in the new TL-14 Tractoloader, Allis-Chalmers has once again used a Twin Disc Converter.

Chances are that a Twin Disc Torque Converter could dovetail perfectly with your drive line plans. Bulletin 508 (single-stage) and Bulletin 135-F (three-stage) may help you decide. We will also be glad to furnish engineering help if you wish.



TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • (Hydraulic Division) Rockford, Illinois

British Attack Bearing Failures with Pressure-Pulse Lubrication

First Details on Ramrod: Cavitation Cure for Bearings

OIL-FILM cavitation—the well-recognized culprit in many a premature bearing failure—may soon become an “historical curiosity.” At least that’s the opinion held by developers of Ramrod, a new lubricating system that injects timed pulses of high-pressure oil into bearings that carry cyclic loads.

Introduced in London last month to U. S., British, and Canadian lubrication specialists, Ramrod grew out of a program of bearing research carried on by the English firm, Glacier Metal Co. Ltd. Work to date has centered on piston-engine applications, with the particular aim of raising the load capacity and service life of connecting-rod and crankshaft bearings. Glacier officials see Ramrod as a

stimulus leading toward the design of engines that are “shorter, lighter, and cheaper for a given power than anything today possible.”

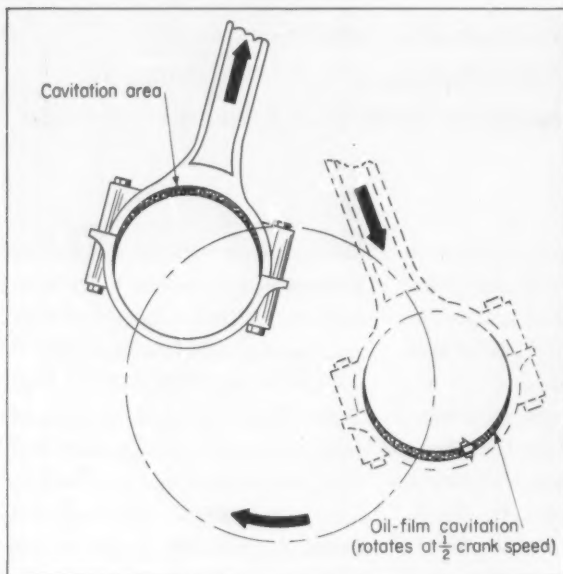
Glacier studied cavitation of cyclically loaded bearings on a test rig that permitted simulation of “big-end” polar loads for two and four-cycle engines. Bearings under test were transparent plastic, so that behavior of loaded oil films could easily be observed.

Under typical two-stroke polar loading, the transparent bearing gave a clear picture of the oil-film collapse (cavitation) occurring under the cap half of a connecting-rod bearing during one-half a firing stroke. Unfortunately, the cavitation area rotates (at one-half crank speed) and, in due course, turns up on the rod side of the bearing. Here (in an actual engine), it exposes the bearing material to the full

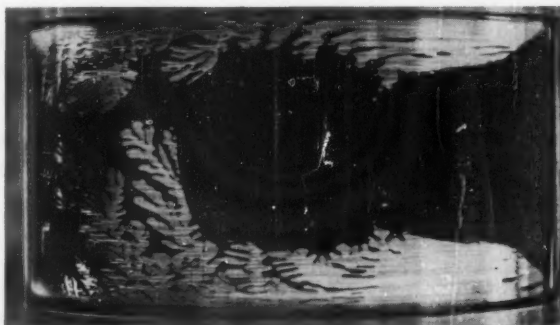
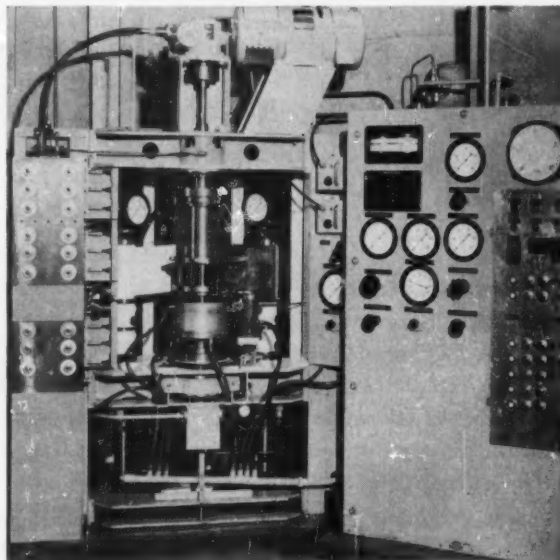
force of a firing explosion without the protection of the oil film that is supposed to separate bearing and crankshaft.

Essence of the Ramrod system is the timed injection of high-pressure oil into the bearing just before the firing stroke. This clears the cavitation area before the bearing comes under peak load. Typical Ramrod pressures on an actual engine would be in the 900 psi or higher range. Necessary injection pumps are claimed to be inexpensive.

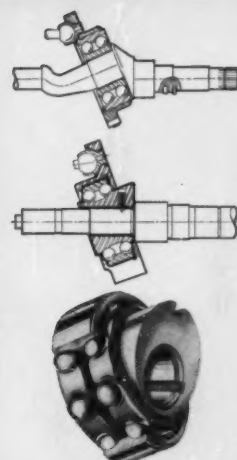
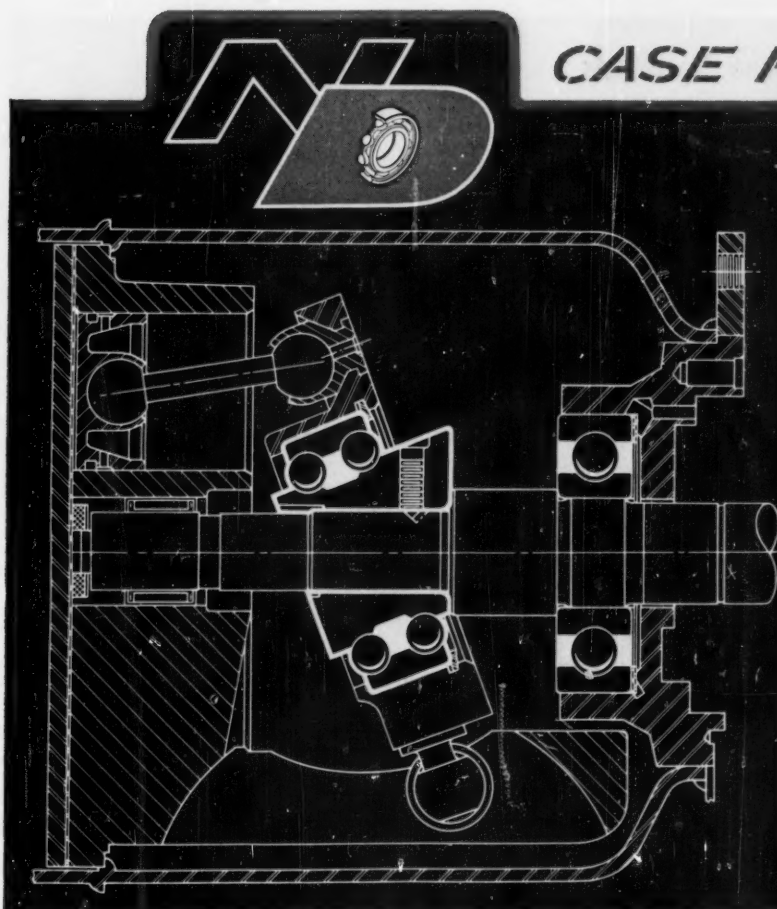
Plans to introduce the new lube system in the U. S. are still indefinite. According to W. D. B. Brown, Glacier Co. chairman: “We don’t feel we can do justice to this development in the United States for we are not a large concern.” Brown said that he would visit the U. S. in the spring to arrange for licensing agreements.



Oil-film cavitation develops under a connecting-rod bearing cap when the force of the firing-stroke drives the cap away from the crank pin (above). Rotating at one-half crank speed, cavitation is particularly serious in the two-stroke engine since it moves to the rod side of the bearing just before each firing stroke. With conventional lubrication, the Glacier bearing-test rig (top, right) showed clearly that positioning crank-pin oil holes at the “best” position (40 deg before TDC) had little effect on the degree of cavitation. To permit observation of oil-film behavior (right), the test rig was run at very low speed (7 rpm). Dynamic similarity with actual engine bearing sizes and speeds was maintained by lowering injection oil pressures and bearing loads, and raising oil viscosities.



CASE HISTORIES



Redesign of high capacity compressor shaft and bearing assembly eliminated costly angled shaft in favor of unique, efficient ball bearings.

Illustration: Courtesy, Frigidaire Division, General Motors Corporation

Unique Wobble Plate Ball Bearing Simplifies Axial Compressor Design!

CUSTOMER PROBLEM:

In developing the ideal compressor for automobile air conditioning unit, customer engineers faced the problem of further design simplification and refinement of pilot model.

SOLUTION:

N/D Sales Engineer, in co-operation with customer, pointed out a possible design simplification in the crankshaft bearing assembly. By providing a specially designed N/D precision ball bearing with shaft bore at an angle, a straight shaft could replace the original pilot model crankshaft. The wobble plate angle would then be supplied by the bearing rather than the shaft. First

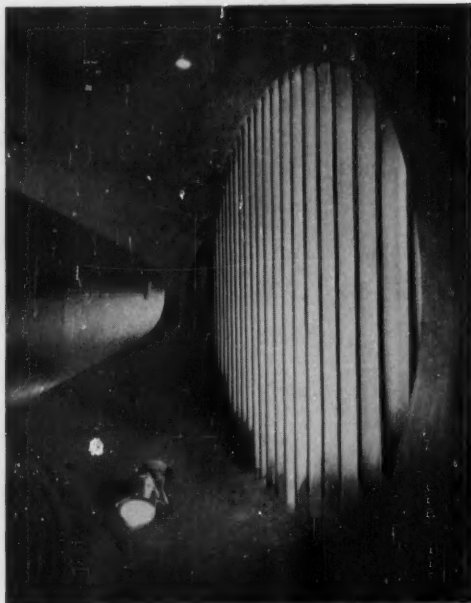
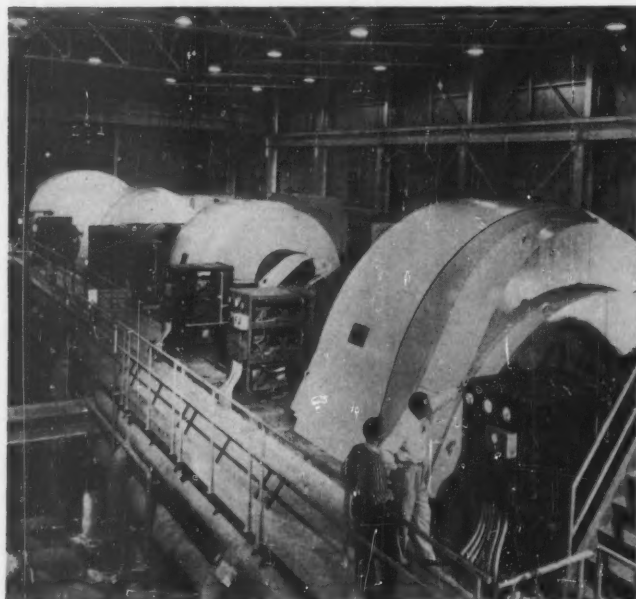
tests proved the new and simpler shaft/bearing assembly met customer's rigid performance standards in high capacity compressor. Final testing of some 300 pilot models, both in the laboratory and on road test cars, finalized the design. Now . . . all GM air conditioner equipped cars are cooled with the aid of N/D ball bearings.

If you're working on new designs . . . or redesigning, why not call your N/D Sales Engineer. He knows the performance possibilities of virtually every ball bearing made . . . and, he knows what can be done with special bearing designs! For more information write New Departure Division, General Motors Corporation, Bristol, Connecticut.



NEW DEPARTURE
BALL BEARINGS
proved reliability you can build around

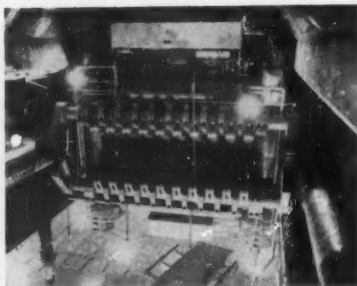
Latest (and Perhaps Last) of the Big Winds



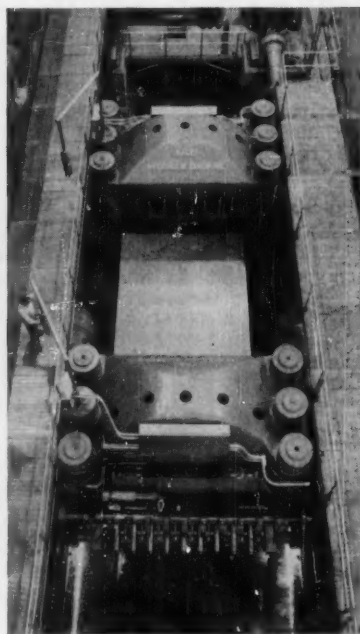
Speeds of 3000 mph and altitudes to 100,000 ft will be simulated in Air Force's new supersonic wind tunnel, now being completed at the Arnold Engineering Development Center, Tullahoma, Tenn. The tunnel, 62 ft in diameter at its widest section, is powered by a Westinghouse four-motor drive system (left). Two of the motors, rated 83,000 hp each, are the largest synchronous motors ever built. The other two are "starting motors" and are rated at 25,000 hp. Motors and compressors (21 stages) make up the world's largest rotating machine. Vertical steel vanes (right) decrease turbulence in the air flow as its direction is altered

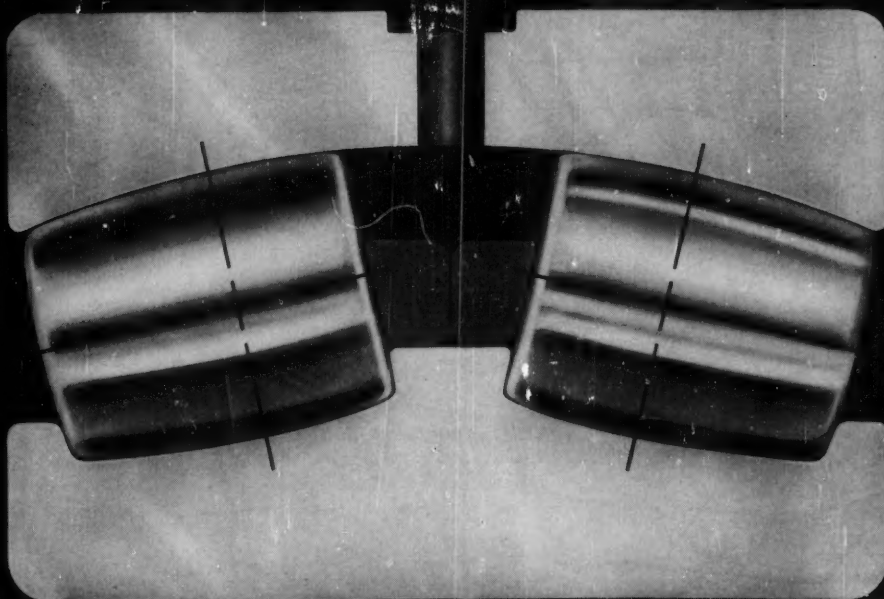
at the wind tunnel's corners. Diameter of the tunnel at this point is 47 ft. Heat formed by air friction is removed by a water-cooling system that circulates 65,000 gallons per minute. The supersonic tunnel, which completes the Arnold installation, parallels a transonic-tunnel branch that is powered by the same four motors. The transonic system has been operational for almost three years, and has been used on such jobs as Titan, Snark, GAM-72, and Bomarc missile development, nose-cone development for ICBMs, and the Mercury "man-in-space" project. The supersonic loop will reveal more details on spacecraft behavior.

Aluminum Rack Exerts 30 Million Pounds



Twice the pull of other machines is produced by Kaiser Aluminum's new 30-million pound plate stretcher. It will stretch a 60-ft long aluminum plate an additional 4 ft, and it can work plate up to 13 1/3 ft wide or 6-in thick. Maximum cross-sectional area the stretcher can handle is 640 sq in. (as compared to a maximum of 350 sq in. possible with other machines). Purpose of the machine is to refine the internal structure of the metal by equalizing stress distribution in heat-treated alloys that are gaining use in industrial and structural applications. The greatest forces encountered in a stretcher of this size are ones which must be absorbed when a plate breaks. To absorb these forces, the stretcher jaw mechanism includes a hydropneumatic system very much like the recoil equipment on a heavy cannon. The oil bypasses the pressure cylinders, allowing the heads to explode apart for a distance great enough to use up this energy. Also, shock absorbers are provided between the foundation and the end of the column.

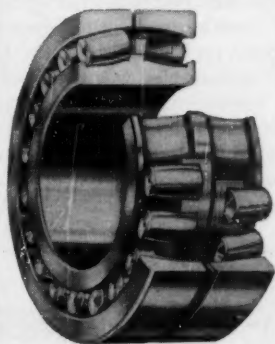




TORRINGTON

Spherical Roller Bearings Offer:

- inherent self-alignment
- conformity of rollers to raceways
- integral center guide flange for stability
- positive roller guidance
- land-riding bronze cages
- maximum radial and thrust capacity
- controlled internal clearance
- electronically selected rollers
- even load distribution
- long, dependable service life



Send for new Torrington
Spherical Roller Bearing Catalog #258.

Shaped for Stability!

The asymmetrical shape of each roller in Torrington Spherical Roller Bearings contributes directly to operating stability and long service life.

The maximum roller diameter is not at the center of the roller. Located towards the center flange, it insures geometric positioning of the roller for positive guidance with free rolling action.

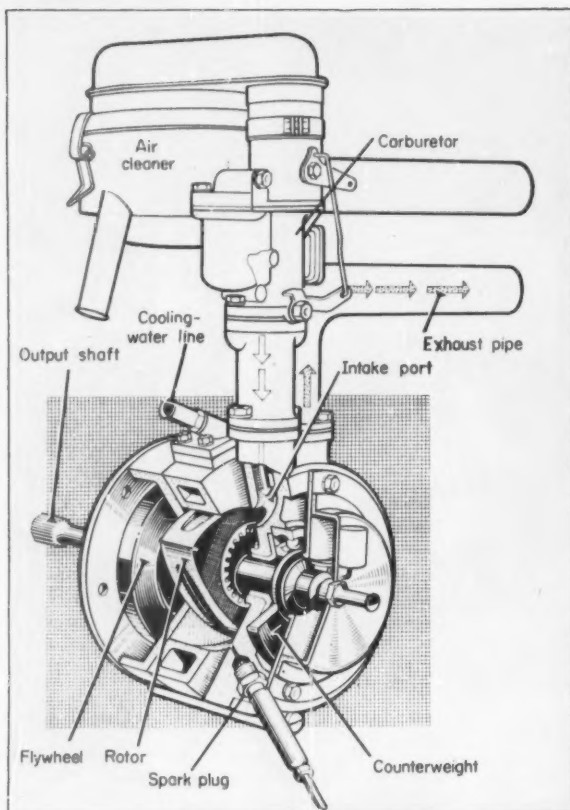
The roller shape also approaches that of a tapered roller. Lines extended from the roller-to-race contact zone converge at the roller and bearing axes. This approach to true conical rolling action further assures stability.

These are two more reasons why Torrington Spherical Roller Bearings operate cooler, quieter and with greater stability. For the ultimate in bearing performance and service life, always specify *Torrington Spherical Roller Bearings*. The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.

TORRINGTON BEARINGS

Every Basic Type of Anti-friction Bearing

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST



Wankel's Rotary: A New Pistonless Powerplant

German Developers Explain the Radical Engine That Curtiss-Wright May Build in This Country

NECKARSULM, WEST GERMANY—A water-cooled, epitrochoidal combustion chamber, accommodating an eccentrically mounted, three-lobed rotor . . . this, in a nutshell, is the secret of the new engine announced recently by Curtiss-Wright Corp. Developed by NSU Werke AG, Neckarsulm, Germany, the revolutionary powerplant operates on the four-cycle principle, with just two moving parts. Agreement between NSU and Curtiss-Wright calls for NSU to continue research on units up to 100 hp, Curtiss-Wright to develop larger powerplants of up to several thousand hp.

NSU's 29-hp prototype, designed primarily for the company's "Prinz" automobile, weighs a mere 24.2 lb, is 7.7 in. in diam and 5.9 in. in length. A conventional air cleaner and carburetor almost dwarf the engine.

Fuel consumption is reportedly the same as a Volkswagen engine (which weighs almost 200 lb).

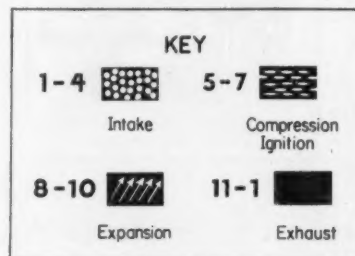
Here's how the mighty midget operates: Within the epitrochoidal combustion chamber, the eccentrically-mounted, three-lobed rotor drives a center-mounted output shaft through internal gear and pinion. Each rotor lobe successively handles intake, compression, expansion and exhaust of the fuel-air mixture. There are three cycles overlapping each other during one full rotor revolution, and the rotor runs at two-thirds output-shaft speed. A single spark plug fires three times for each revolution.

Essentially, the engine needs only two moving parts, rotor and output shaft, but these are supplemented by a flywheel and counterweight, for balance. Sealing problems are said to be solved by metal ridges which correspond to conventional engine's piston rings. Since sealing is apparently the real secret, few details were released.

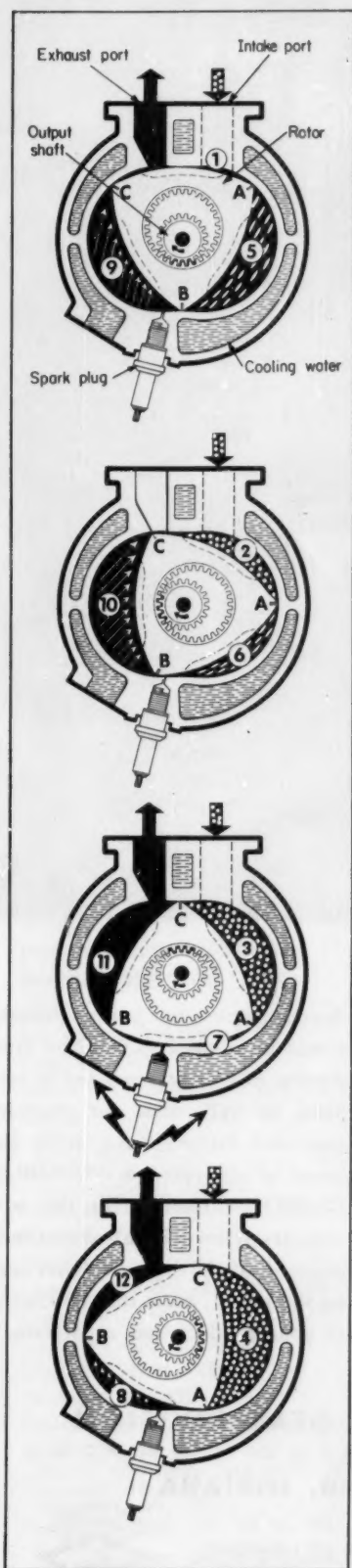
The new engine is a brainchild of Felix Wankel, who teamed with

Prototype of Wankel's engine, designed for NSU's Prinz automobile, delivers 29 hp at 17,000 rpm. Chamber volume, corresponding to a piston engine's displacement, is 7.63 cu in.

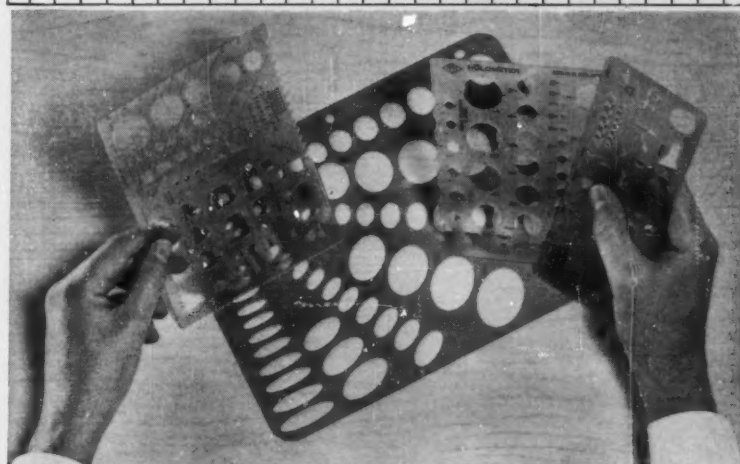
NSU in 1951. Wankel, an independent inventor, is recognized as an expert on sealing problems and holds numerous patents on rotary, roller, and disc valves for internal-combustion engines. His latest invention was first tried in 1956, when NSU gained world fame by establishing small-motorcycle records on Utah's Salt Lake. One of the motorcycles was equipped with a compressor operating on the epitrochoidal chamber, three-lobed rotor principle. The first combustion engine of this type performed trial runs on February 1, 1957.



The Wankel Cycle



DRAFTING TRENDS



Drafting Templates are a valuable tool to faster drafting. They are available in an almost endless variety.

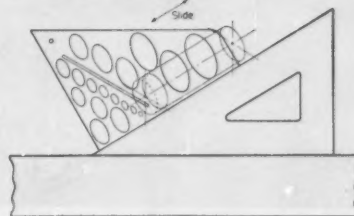
Specialized drafting templates speed drawing time

Always a handy tool, drafting templates are becoming increasingly in use to simplify everyday drawing techniques. Now vinyl plastics are used in the manufacture of the majority of templates. But the thickness, color and finish vary in almost endless profusion. Glare-saving colors, such as green and amber, are usual, both in clear and matte finishes. However, the white and clear plastics still are popular. The thicknesses vary with the different types of available templates from .020 gauge through .070 gauge.

Specialized template applications

A list showing the growing application for templates includes templates for: Electronic Symbols, Electrical Wiring, Landscaping, Screw Heads, House Plans, Nuts and Bolts, Screw Threads, Tooling, Windows, Plumbing, Mathematical Symbols, Map Planning, and many "all-purpose" templates for circles, ellipses, triangles, and other shapes.

Isometric ellipse template is a big timesaver



An isometric ellipse template may be more useful if it is cut in half to provide edges parallel to the minor axes of the ellipses. Halves of the template may then be moved along a 30-60 degree triangle so that ends of a shaft or any cylindrical shape can be drawn in a minimum of time and in perfect alignment.

A selection of 52 popular templates is illustrated and described in a special six page brochure, "Drafting Templates" recently published by Frederick Post Company. For your copy, write Frederick Post Company, 3652 N. Avondale Ave., Chicago, Illinois.



SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE



**NEW
GIANT
AT WORK
on
Double Diamond
Gears**

This huge, continuous, carburizing, hardening and draw furnace now permits even greater instrument control in heat treating **DOUBLE DIAMONDS** for maximum wear resistance and load-carrying capacity. So far as we can discover no more efficient furnace could be installed to achieve the quality characteristics our gear customers have come to expect.

At your request, our gear engineers would be pleased to describe this process in greater detail and to explain, as well, what our recently expanded facilities can mean in terms of this pledge: "DOUBLE DIAMOND Gears offer the advantages of lower installed cost and economical and dependable service on the job...gears that do credit to your product and reputation."

EATON

**AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA**



GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS



Circle 412 on Page 19

Reader Information Service

SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

- Accumulators, Adv. 172
- Actuators, Adv. 27
- Adhesives, Adv. 172
- Automobiles, Edit. 6, 36
- Batteries, Edit. 133
- Bearings,
 - ball, Edit. 206; Adv. 11, 48, 173, 177
 - miniature, Adv. 177
 - rod-end, Adv. 207
 - roller, Adv. 13, 88
 - sleeve, Adv. 185
- Belts,
 - conveyor, Adv. 209
 - transmission, Adv. 2, 29, 75, 83, 179
- Blowers, Adv. 201
- Books, Edit. 168
- Brakes, Edit. 188
- Brass (see Copper and alloys)
- Bronze (see Copper and alloys)
- Cabinets, Adv. 199, 209
- Cams, Edit. 127
- Carbon and graphite parts, Adv. 178
- Castings,
 - die, Adv. 174
 - ductile-iron, Adv. 183
 - malleable iron, Adv. 70
 - permanent mold, Adv. 164
 - steel, stainless, Adv. 62, 105
- Chemicals, Edit. 22
- Clamps, Edit. 179; Adv. 101, 210, 212
- Clutches, Edit. 120; Adv. 40, 67, 194
- Compressors, Adv. 41
- Computers, Edit. 39; Adv. 68
- Connectors, electric, Adv. 215
- Contactors, Edit. 123
- Control systems, electric, Adv. back cover
- Controls,
 - electric, Adv. inside front cover, 192
 - hydraulic, Adv. 217
 - pneumatic, Adv. 217
- Copper and alloys, Adv. 69, 81, 193
- Counters, Adv. 104
- Couplings,
 - fluid flow, Edit. 195; Adv. 192
 - shaft, Edit. 176; Adv. 67, 80
- Cylinders,
 - hydraulic, Edit. 193; Adv. 87, 98, 109
 - pneumatic, Adv. 98
- Diaphragms, Adv. 211
- Differentials, Edit. 136
- Drafting equipment, Edit. 199; Adv. 15, 60, 100, 200, 206, 216
- Drives, adjustable speed, Adv. 7, 92, 182, inside back cover
- Drives, right-angled, Adv. 96
- Ducts, Edit. 184
- Education, engineering, Edit. 23
- Electric equipment (see specific type)
- Electronic design, Edit. 166
- Enclosures, Adv. 180
- Engineering department (see Management or Drafting)
- Engineers' interests, Edit. 25
- Engines, Edit. 14; Adv. 50
- Fans, Adv. 49
- Fasteners,
 - bolts, studs, screws, Edit. 122; Adv. 107, 169, 181, 208, 217
 - nuts, Edit. 182; Adv. 63, 110, 187, 214
 - pin, Adv. 73
 - quick operating, Edit. 176
 - rivet, Adv. 37, 63
- Filters, Adv. 24
- Fittings, pipe, tube, and hose, Edit. 184; Adv. 5, 167, 215
- Forgings, Adv. 82
- Gages (see Instruments)
- Gas damper, Edit. 204
- Gaskets, Adv. 53
- Gears, Edit. 155; Adv. 16, 86, 165, 210, 213, 216
- Heat exchangers, Adv. 197
- Heaters, Adv. 99, 212
- High-temperature alloys, Adv. 106
- Hose,
 - metallic, Adv. 5
 - nonmetallic, Adv. 167
- Hydraulic equipment (see specific type)
- Instruments, Edit. 8, 32, 198; Adv. 74, 207
- plotter, Edit. 134
- Inventions, Edit. 36
- Jacks, worm gear, Adv. 190
- Lighting, Edit. 193
- Lubricants, Adv. 211
- Lubrication,
 - equipment, Adv. 45, 77
 - systems, Edit. 10; Adv. 42
- Machining, electrical discharge, Edit. 165
- Magnets, Edit. 164; Adv. 180
- Management, engineering, Edit. 8, 23
- Meetings, Edit. 39
- Metals, general report, Edit. 6
- (also, see specific type)
- Motors, (electric)
 - fractional and integral hp, Edit. 190; Adv. 66, 90, 94, 102, 108, 166, 175, 195, 198, 212
 - gearmotors, Adv. 78
 - subfractional hp, Edit. 186; Adv. 78, 90
- Motors, hydraulic, Edit. 185
- Nickel and alloys, Adv. 55
- Oscillographic recorders, Edit. 200
- Packings, Adv. 163
- Pipe, Edit. 204
- Plastics, molding, Edit. 34, 36, 194; Adv. 51, 53, 95, 97, 185, 186
- Plugs, Adv. 213
- Pneumatic equipment (see specific type)
- Positioner, Edit. 176, 180
- Potentiometers, Edit. 194
- Powder metallurgy, Edit. 38; Adv. 84
- Power supplies, Edit. 201
- Printed circuits, Edit. 161, 178, 196; Adv. 46

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries, generally

SUBJECT INDEX (continued)

Product design review committee, Edit. 112
Products, new, Edit. 23

Pumps

hydraulic, Edit. 122, 192; Adv. 174, 191, 198, 222
pneumatic, Edit. 200
Punches, Adv. 166
Pushbuttons, Adv. 35

Recorders, Edit. 198, 199

Rectifiers, Edit. 164

Reducers, speed, Adv. 1, 67, 78, 188, 203, 214

Relays, Edit. 190; Adv. 65, 171, 189, 210, 213

Reports, engineering, Edit. 164

Resistors, Adv. 59

Rheostats, Adv. 59

Rotation, positioning by, Edit. 116

Rubber, molding, Adv. 95, 214

Sealants, Edit. 187

Seals, Edit. 144, 204, 206; Adv. 21, 39, 53, 163

Servo circuits, Edit. 139

Shapes, special, Adv. 58, 86

Slide rule, Adv. 38

Slip rings, Edit. 154, 185

Solar cells, Edit. 180

Solenoids, Adv. inside front cover

Springs, Edit. 188; Adv. 208

Stampings, Adv. 217

Standards, Edit. 22

Steel, Adv. 208

bars, rods, and rolls, Adv. 33
stainless, Adv. 84, 91, 196

Switches, Edit. 179, 187, 189, 197; Adv. 31, 35, 59, 207, 209, 212, 215

Swivel joints, Adv. 211, 214

Tables, indexing, Adv. 184

Terminals, Adv. 72

Testing, fatigue, Edit. 124
impact, Edit. 124
wind tunnel, Edit. 12

Timers, Adv. 44, 160, 202

Titanium, Adv. 84

Torque converters, Adv. 9

Transistors, Edit. 183

Transmissions, adjustable speed, Edit. 30, 121, 176; Adv. 216

Tubes, electronic, Edit. 23

Tubing, Adv. 52, 58, 76

Valves, Adv. 216

hydraulic, Edit. 182, 196, 197; Adv. 56, 204, 208
pneumatic, Edit. 176, 182, 195, 196; Adv. 56, 204

Vehicles, off road, Edit. 145

Wire and wire products, Adv. 209

Wrenches, Adv. 215

Yttrium, Edit. 22

USE A YELLOW CARD for More Information...

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature BY ITEM NUMBERS

HELPFUL LITERATURE—descriptions start on page 168

ITEM NUMBER	ITEM NUMBER
Pushbutton Switches	601
PNP Phototransistors	602
Power Connectors	603
Coolant Pumps	604
Static Switching	605
Aluminum Joining	606
Pipe Fittings	607
Electric Motors	608
Carbide Hard-Facing	609
Pneumatic Calibrator	610
Plastic Components	611
Power Supplies	612
Chemical Pumps	613
Power Transistor Pairs	614
Potentiometers	615
Rotary Solenoids	616
Electric Motors	617
Silicone Rubber	618
Wire-Wound Resistors	619
Two-Circuit Switches	620
Pipe Branch Connections	621
Ball Bearing Retainers	622
Screw Thread Form	623
Copper Base Alloys	624
Teflon Coatings & Finishes	625
Threaded Fasteners	626
AC Test Sets	627
Preventing Metal Corrosion	628
Polyester Molding Compounds	629
Steel Analysis Guide	630
Circuit Breaker	631
Curtain & Cover Materials	632
Soldering Supplies	633
Spray Nozzles	634
Recorder Timers	635
Thermal Discs	636
Infrared Materials	637
Office Copying Machines	638
Hydraulic Filters	639
Carbide Cutting Tools	640
Industrial Crystals	641
Blind Rivets	642
Corrosion Inhibitor	643
Alloy Tubing & Pipe	644
Fusible Terminal Blocks	645
Time-Delay Relays	646
Pipe Fittings	647
Conveyor Wheels & Trolleys	648
Permanent Magnet	649
Transistors	650
Selective Plating	651
Panel Instruments	652
Flow Indicator	653
Protecting Drawings	654
Thermostats	655
Pumps	656
Electric Eyes	657
Potentiometers	658
Digitizing System	659
Tone Switch	660
Seamless Tubing	661

NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 176

ITEM NUMBER	ITEM NUMBER
Quick-Release Pins	662
Miniature Transmission	663
Flexible Coupling	664
Needle Valve	665
Positioning Device	666
Printed-Circuit Connectors	667
Self-Aligning Clamps	668
Two-Circuit Switches	669
Silicon Solar Cells	670
Linear Positioning Motor	671
Midsize Nut	672
Solenoid Valves	673
Silicon Transistors	674
Fittings and Pipe	675
Flexible Duct	676
Hydraulic Pump Motors	677
Slip-Ring Assembly	678
DC Motors	679
Light-Operated Switch	680
One-Part Sealant	681
Small Brake	682
Liquid Spring	683
Enclosed Switch	684
Time-Delay Relay	685
Shaded-Pole Motor	686
Gear Pumps	687
Power Cylinders	688
Nonflare Light	689
Delrin Rods	690
Trimming Potentiometer	691
Air-Control Valve	692
Reducer Couplings	693
Printed-Circuit Laminate	694
Solenoid-Operated Valve	695
Switch and Light	696
Hydraulic Control Valve	697
Strip-Chart Recorder	698
Miniature Torque Pickups	699
Nonreproducible Paper	700
X-Y Recorder	701
Display Oscilloscope	702
High-Vacuum Pumps	703
Power Supply	704

MACHINE DESIGN JAN. 7, 1960

Circle item number for information on products
advertised or described or copies of literature.

401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE
Page No. Title of Article

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE _____

STATE _____

Do not use this card after March 7, 1960

MACHINE DESIGN JAN. 7, 1960

Circle item number for information on products
advertised or described or copies of literature.

401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE
Page No. Title of Article

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE _____

STATE _____

Do not use this card after March 7, 1960

MACHINE DESIGN JAN. 7, 1960

Circle item number for information on products
advertised or described or copies of literature.

401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

BUSINESS REPLY MAIL

No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—


MACHINE DESIGN

Penton Building

Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO



BUSINESS REPLY MAIL

No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—


MACHINE DESIGN

Penton Building

Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO



BUSINESS REPLY MAIL

No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—


MACHINE DESIGN

Penton Building

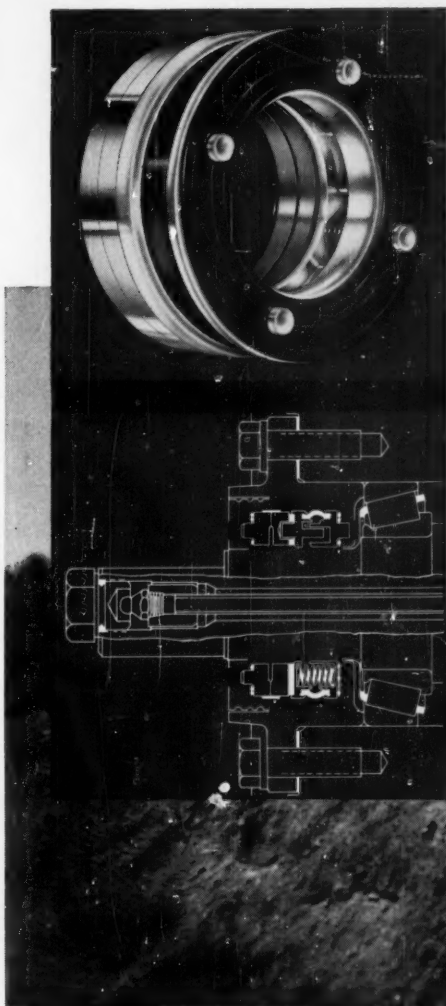
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO



Belly-deep in abrasives!



But it can't touch her track wheel bearings

Whatever the Oliver OC-12 is bulling through . . . liquid ooze, dirt, or gale-blown desert sand . . . nothing can get into the track wheel bearings. Oliver engineers saw to that. They specified C/R Type VS End Face Seals with metal-to-metal contact to protect those bearings. The metal faces in these seals are lapped to within 3 lightbands of being optically flat. Nothing can get in . . . and the fluid lubricant inside can't get out . . . no matter how rugged the duty. Oil seal dependability like this means fewer lube checks, fewer lube changes . . . less downtime. And that means big savings for Oliver users.

C/R End Face Seals are performing hundreds of other critical sealing jobs . . . saving equipment, time and money. No matter what is involved . . . high speed, temperature, pressure . . . in everything from rockets and missiles to pumps, tools and washing machines . . . there's a C/R End Face Seal for the job. If it's *your* job to solve a difficult lubricant retention problem . . . share it with us. Write for detailed information on C/R End Face Seals.

More automobiles, farm and industrial machines rely on C/R Oil Seals than on any similar sealing device.

CHICAGO RAWHIDE MANUFACTURING COMPANY

OIL SEAL DIVISION: 1221 ELSTON AVENUE • CHICAGO 22, ILLINOIS

Offices in 55 principal cities. See your telephone book.

In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario

Export Sales: Geon International Corp., Great Neck, New York

C/R Products: C/R Shaft and End Face Seals • Sirvene (synthetic rubber) molded pliable parts • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears



how many zeros in a giga?

National Bureau of Standards is using the International Committee on Weights and Measures' new prefixes for denoting multiples and submultiples of units. In addition to the eight prefixes in common use, the Committee recommends four new ones. For example, 10^{-12} farad is called one picofarad and is abbreviated 1 pf. Here is the complete list:

Multiplier	Prefix	Symbol	Multiplier	Prefix	Symbol
10^{12}	tera	T	10^{-1}	deci	d
10^9	giga	G	10^{-2}	centi	c
10^6	mega	M	10^{-3}	milli	m
10^3	kilo	k	10^{-6}	micro	μ
10^2	hecto	h	10^{-9}	nano	n
10	deka	dk	10^{-12}	pico	p

Q award—for quantity and quality production

"We are engaged in a war of workmanship," says Robert S. Bell, president, Packard Bell Electronics Corp., Los Angeles. Mr. Bell wants industry and government to start a program of "Q" awards—much like the "E" awards given out during the shooting war—for quantity and quality production. "Only through quantity can we fight inflation and compete in foreign markets; only through quality can we prevail in any market." He continues: We have a head start, but our Central Intelligence Agency thinks that if Soviet growth persists at the present rate, the gap between the two economies will be dangerously narrowed by 1970. Today, the United States stands almost at the bottom of the list of major nations in terms of annual rate of economic growth. Packard Bell is now using the Q-award plan in its own factories.

up comes yttrium

Look for lots of new uses for yttrium, a member of the rare-earth family. The metal reportedly holds promise as a reactor material in nuclear aircraft, and as an alloying agent, where it effectively increases resistance to oxidation at high temperatures. A little yttrium added to stainless steel, for example, gives the alloy the same oxidation resistance at 2500 F as it previously had at 2000 F. "Pinches" of yttrium also make most alloys easier to work.

nuclear reactor manufactures chemicals

A new type of nuclear reactor produces commercial chemicals by treating organic raw materials. Designed and patented by Hercules Powder Co., Wilmington, Del., the reactor is expected to compete pricewise with conventional methods of chemical manufacture. It effectively utilizes the "fragment recoil energy" of nuclear fission. Recoil energy, constituting about 80 per cent of the total fission energy, is normally absorbed in the fuel and its container. The company believes the reaction works best with lower molecular weight chemicals. For example, yields of over 65 per cent ethylene glycol have been obtained from methanol. Methanol sells at about 4½ cents per pound, ethylene glycol sells at about 14 cents per pound.

dollars for college research: too many strings?

Over 10,000 research projects are underway at engineering colleges across the nation. Expenditures during 1959 totaled over \$112 million. According to the Engineering College Research Council of the American Society for Engineering Education, Urbana, Ill., these figures are the largest ever compiled. "In addition to keeping our engineering colleges abreast of current needs and problems, this basic research will be the foundation for our nation's technological superiority in the years to come," says ECRC's chairman, Kurt F. Wendt. But all educators don't agree. Some believe colleges are in danger of surrendering their independence to the donors of research dollars. Discoveries coming from the independent researcher who follows his own paths are less frequent. Some educators feel funds should be made available for colleges to use as they see fit.

electrically cold cathodes get nuclear heat

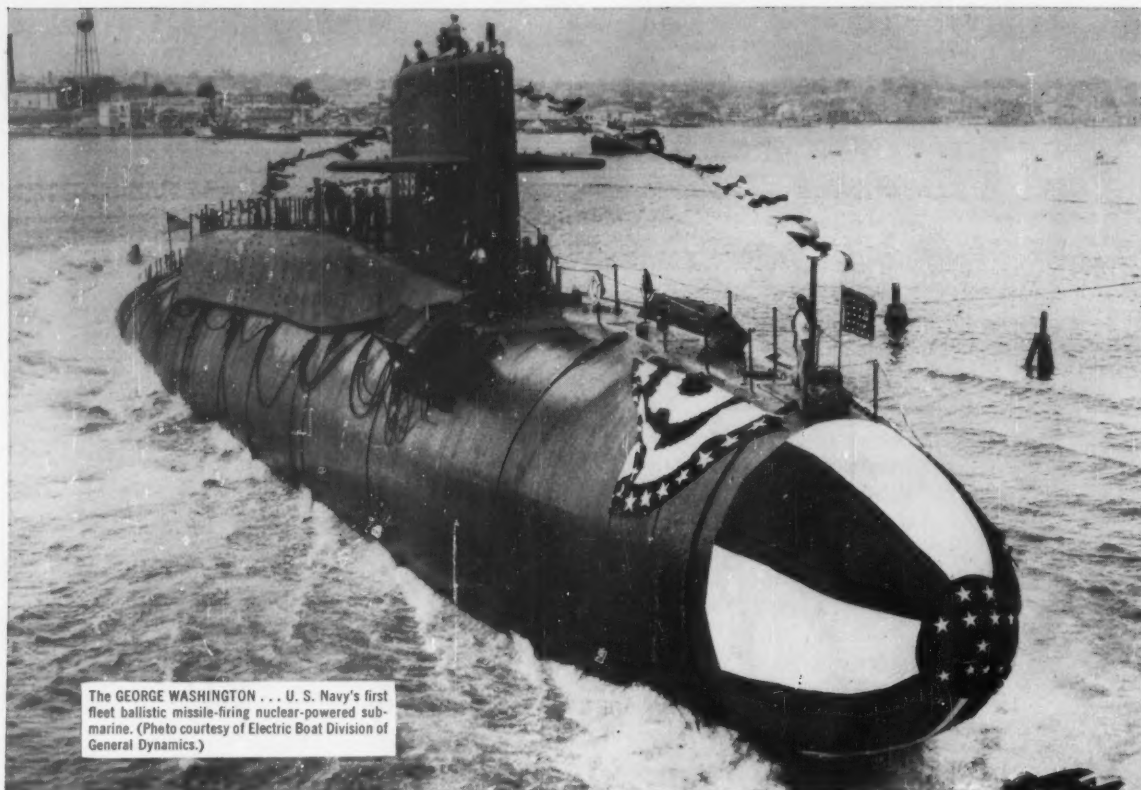
Electronic tubes that need no electric input to heat their cathodes may soon influence the tubes vs. transistors struggle. A radioisotopic heater for cathodes is under development at Nuclear Div., Martin Co., Baltimore. Since a large percentage of tube power normally goes into cathode heat, use of self-heating tubes is expected to cut size and weight of power packs by about 50 per cent.

faster development of new products predicted

Pace of product evolution will quicken as we enter the 1960s, predicts William F. Crawford, vice president, Rockwell Mfg. Co., Pittsburgh. New products will remain competitive for no longer than five years without major redesign. Increasingly greater push behind research and development programs will relieve competitive pressures and insure corporate survival, but it will also accelerate competitive obsolescence, he forecasts. Success will come to those firms whose present plant, equipment, and people are best suited to future jobs rather than to those firms who are concerned only with the jobs they perform today.

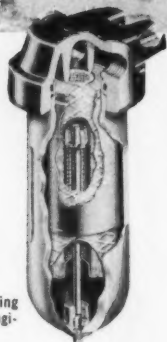
a difference is important

"We have reached the end of the era when style obsolescence can be a prime mover of goods . . . and management today runs a great risk if it claims its products are really new, when actually they are not," according to J. Richard Lippincott, chairman of the board of Lippincott & Margulies, Inc., industrial designers. He told AMA's recent Product Design & Development Forum "that Americans eagerly anticipate new and improved products—the fruits of research and development . . . but in product line after product line, sameness is evident. The research and development goal is clearly outstanding innovation, teamed of course, with effective appearance design," he said. "This means that the industrial designer must think in terms of people who will use the machine . . . and he must also be able to speak the language of the engineer—in terms of today's broad spectrum of materials and methods."



The GEORGE WASHINGTON . . . U. S. Navy's first fleet ballistic missile-firing nuclear-powered submarine. (Photo courtesy of Electric Boat Division of General Dynamics.)

EVEN UNDER THE SEA *Fulflo Filters* GUARD PNEUMATIC EQUIPMENT



This standard Fulflo Filter is designed for operating pressures of 4,000 psi. Special models can be engineered for even higher pressures.

The *George Washington* will be the first submarine to fire the Polaris missile from submerged positions at sea. We are proud that Fulflo Filters were selected to protect the pneumatic equipment on this great ship . . . destined to play a vital war deterrent role for the free world.

Fulflo Filters, with patented Honeycomb Filter Tubes, minimize troublesome gumming — remove moisture, oil, microscopic rust, dust, dirt

and scale from your air lines. Single-tube models are designed for pressures from 125 to 4,000 psi. Multi-tube models are available for large flow rates or central installations.

CFC Filters also provide micro-clarity for other industrial fluids — liquid chemicals, oils, pharmaceuticals, hydraulic fluids, diesel fluids, plating solutions, water, CO₂ and other gases.

Write for catalog to Department MD.

COMMERCIAL FILTERS CORPORATION

MELROSE 76, MASSACHUSETTS

PLANTS IN MELROSE, MASSACHUSETTS AND LEBANON, INDIANA

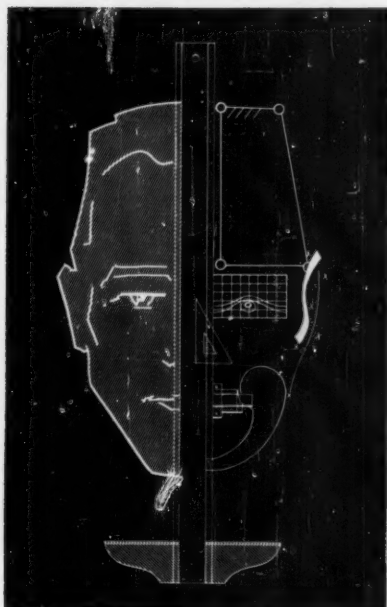
MICRO-CLARITY AT MINIMUM COST



with genuine Honeycomb Filter Tubes for controlled micro-clarity of industrial fluids.



Selective filtration of oils • water-oil separators • magnetic separators • pre-coat filters • coolant clarifiers • automatic tubular conveyors.



The Engineer:

Paragon or Paradox?

►► Part 3 – His Interests

What's the engineer really like? To nail down answers to this question, psychologists try to find out what he enjoys and what he freely chooses, i.e., what his "interests" are. Here's a summary of what they've learned.

EUGENE RAUDSEPP
Research Consultant
Deutsch & Shea Inc.
New York

WHAT would you do for a living if you couldn't be an engineer? Engineers taking the Strong Vocational Interest Test rate the vocations this way: 1. Engineer. 2. Chemist. 3. Math-science teacher. 4. Carpenter. 5. Printer. 6. Production manager. 7. Aviator. They rate both Mathematician and Physicist low, which indicates that, while they have a strong practical orientation, they lack theoretical and research interests.

What would you least like to be? Moore and Levy (in "Artful Contrivers: A Study of Engineers") found that engineers rate the least interesting occupations as: 1 Minister. 2. City school superintendent. 3. YMCA secretary. 4. Artist. 5. Banker. 6. Real estate salesman. 7.

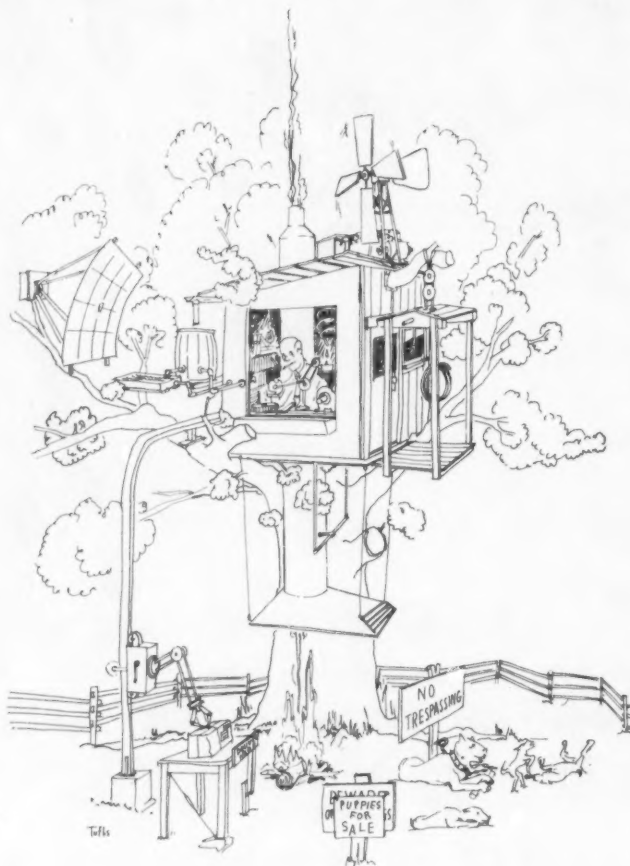
Lawyer. 8. Author-journalist. 9. Advertising man. Evidently, engineers are neither service nor human-relations-minded and they are primarily nonverbalists.

Occupational Interests

Harrison, Tomblen, & Jackson (in "Profile of the Mechanical Engineer") showed the following:

- Engineers like technical, mechanical, mathematical, and physical science activity much more than do other men and they avoid selling, advertising, publicity, routine office work, and public contact and display in general. They do not seem to enjoy work where personal relationships are paramount. Of special interest is the observation that they do not react

The Keynote: Self-Sufficiency



Psychologists say that if engineers could voice their unconscious values, they would arrive at a "design for living." If management, the psychologists continue, would recognize this life design for what it is—an expression of primary motivation—and would consider it when establishing or reviewing company policy, much could be done toward improving relations with the engineering staff. Here are high points in the design:

- Friendship is valued, but not intimacy. One should be able to stand alone, avoiding dependence on others.
- Interests and hobbies should preclude intimate associations. Social interests should be only moderately indulged. Neither extroverted sociability nor self-sacrifice for social causes are necessary for enriching one's life or person.
- Physical and psychological withdrawal, restraint, and rational and intellectual orientation are conducive to orderly living.
- Life should be faced realistically. There is little place for excessive desires, feelings, and enthusiasms.
- Man and machine must work together. Man should and can depend upon the technical advances made possible by scientific knowledge, and he must constantly strive to improve the techniques needed to manipulate and control his physical environment.

strongly one way or the other to the peculiarities of people.

G. S. Speer (in "The Vocational Interests of Engineering and Non-Engineering Students") found that mechanical, chemical, civil, and electrical engineers make up a definite scientific-minded engineering group whose interests are high on the computational, scientific, and mechanical scales, low on the persuasive, and average on the other scales. Research engineers, according to his study, form a distinct subgroup and rank highest on scientific interests. Speer also found that sales and other "non-science" engineers are high on the computational and

persuasive scales, average on mechanical and scientific scales, and low on the rest.

Several studies shed light on engineers' paramount interest in technical subjects which are directly or indirectly related to engineering. Drafting is the least popular and mathematics, contrary to its low score on the Strong Test, is the most popular course in college. Apparently the instrumental value and logical rigor of mathematics are favorably regarded by engineers, although their concrete-mindedness and practical orientation preclude any full-time absorption in this interest.

Even though engineers are increasingly exposed to the liberal arts and social sciences at college, these fields have very little appeal. Likewise, the more personally expressive activities, such as drama, art, band, etc., are mentioned by only a few engineers. Their most disliked college subjects are: English, chemistry, economics, and history. They are also notorious for the amount of misspelling on written tests.

Reading Preferences

Although engineers' median scores on intelligence tests fall at approximately the 90th percentile of the

general population, their favorite periodicals are the mass-circulation magazines. They are also avid readers of technical journals, but only such journals that either closely relate to their work or cater to their hobbies. They avoid both the high-brow, cultural periodicals and the low-quality magazines, thus revealing their characteristically middle-brow preferences.

The Harrison study revealed that only 42 per cent of engineers are regular book readers. Technical interests predominate, followed by best-sellers, historical novels, adventure stories, and mysteries. This again brings out the muscular middle-brow frontier-toughness complex in their preferences. Only a few "tender-minded" engineers read classics or semiclassics, and even fewer read books on philosophy, psychology, social science, public affairs, and fine arts.

Considerable evidence is offered by several investigators that the parents of most research and development engineers gave them early encouragement to seek knowledge. These men seem to have grown up with the idea that knowledge should be acquired for its own sake—that accumulation of knowledge enriches life. Perhaps because of these early impressions, most of the really omnivorous readers among engineers are found in the research and development activity. Habits learned young sometimes persist throughout the entire life-span. Design and product engineers do not show such avid interest in books.

Social-Recreational Interests

The bulk of engineers, despite their greater interest in things than in people, indulge in the usual social activity. There is no indication of complete social isolation. Rather, they are heavy practitioners in dating, dancing, movies, parties, and other activities bearing the stamp of popular appeal.

In recreational activities, mechanical hobbies predominate, followed by sports and outdoor life. Moore and Levy state it this way:

- In adult life, the most prominent in-

This revolutionary Carter Rotary Torque Actuator gives engineers a whole NEW field of design opportunities! Up to 370° of rotary fluid power as standard... Safe, powerful torque from air, oil, gas or water power. Zero leakage! Built in cushions! Infinite positioning flexibility! Thousands of applications!

ROTARY

TORQUE ACTUATOR

0-100°

0-190°

0-280°

0-370°

as standard

**PNEUMATIC or
HYDRAULIC**

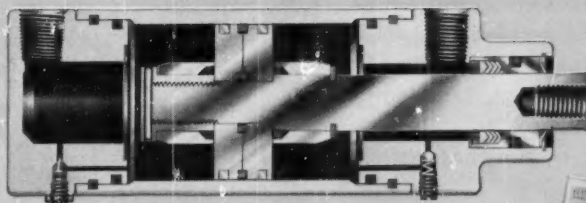


Patents
Pending

Send for 12-page
Bulletin with com-
plete engineering data.



CARTER offers unlimited cost-cutting design opportunities through industry's only **COMPLETE LINE** of **LINEAR** and **ROTARY** fluid power actuators!



HYDRAULIC AND PNEUMATIC CYLINDERS

LINEAR

Complete Catalog File!

Complete bound file with ordering details for: Air Cylinders, 750 PSI Hydraulic, 1500 PSI Hydraulic, Clamp Cylinders, Air Valves, Built-in Valve Types. Complete with parts data, specifications and prices. Send today!



1. Space saving designs! Light weight!
2. Full 1 to 1 Meehanite cartridge rod bearing.
3. Precision honed heavy wall tubing—6 to 1 safety factor.
4. Spring loaded "V" packing on rod end gland.
5. Key type stainless steel locking ring. Allows 360° rotation of pipe ports.

IMMEDIATE DELIVERY ON ALL STANDARD CYLINDERS AND ACTUATORS

CARTER

CONTROLS, INCORPORATED

2914 Bernice Road • Lansing, Illinois
(Chicago Suburb)

Phone: BAyport 1-7186 (Chicago)

GRanite 4-3305 (Lansing, Ill.)

terests and hobbies are photography, sports, and home activities. The interest in team sports is largely from the spectator angle; in addition there is participation in such activities as golf, bowling, and fishing. In keeping with their family orientation is the notable interest in gardening, home repair and crafts.

A large portion of their free time is occupied with either athletic participation or attendance at team events. Coupled with sports, there is genuine fondness for outdoor life.

Although possessing high IQs, they are unaesthetic and nonintellectual in the direction of their interests. They also show very little interest in social sciences and social

service. Harrison and his collaborators conclude:

- Their interests are pretty much confined, aside from ordinary social activities, to the mechanical-technical on the one hand and to the athletic-outdoor life on the other. Constricted interests are apparent in their relative indifference to human relations, to psychology and the social sciences, to public affairs and social amelioration, to the fine arts and cultural subjects and even to those aspects of physical science which do not immediately relate to engineering.

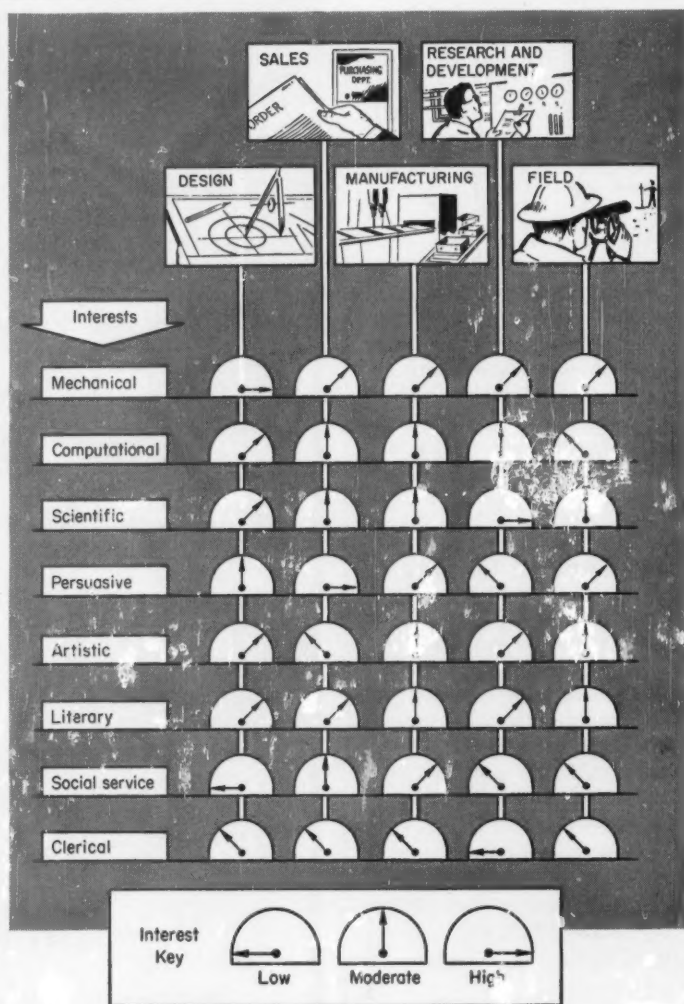
Although most engineers indulge in the usual social activities and hobbies, there are a considerable number who do not. These men

say that they have little time for recreation, that "their work is their life." What leisure time they do have is spent with their families or in individualistic pursuits. When they are "able to get away," they enjoy hiking, hunting, fishing, or some other noncompetitive activity that will guarantee their isolation.

This article concludes Mr. Raudsepp's series on the engineer. Earlier parts appeared in the December 10 and December 24 issues of MACHINE DESIGN and were concerned with the engineer's personality (Part 1) and his intelligence and abilities (Part 2).

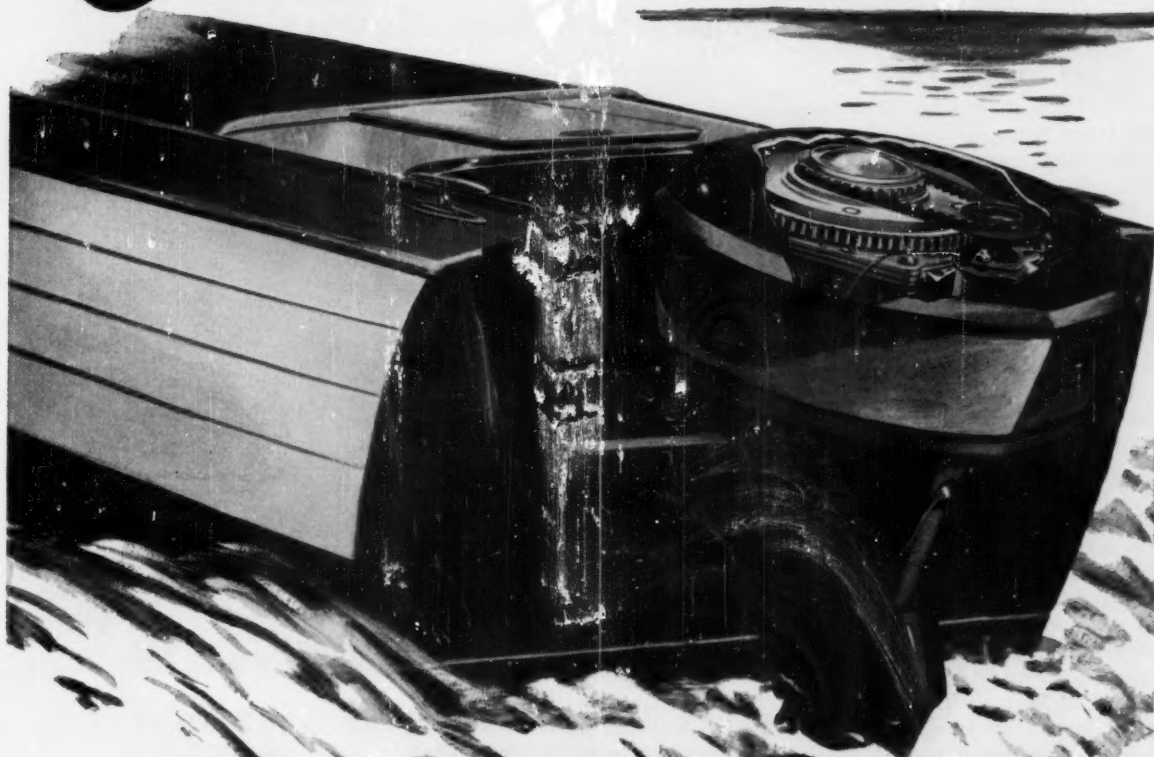
Interests and the Job

It's no surprise that engineers doing different jobs have different interests. Research engineers and sales engineers, for example, might be expected to score differently on scientific interests and on social interests. But how do other groups compare? The Alis-Chalmers study, "Scientific Selection of Engineering Personnel" shows all engineers like gadgets and gadgeteering (they score high on mechanical interests), all dislike doing their own filing (they score low on clerical interests). But in the majority of interest categories, their scores vary "all over the map."





PowerGrip "TIMING" BELT from the Power Unlimited complete belt line



Why are today's outboards streamlined, faster, dependable?

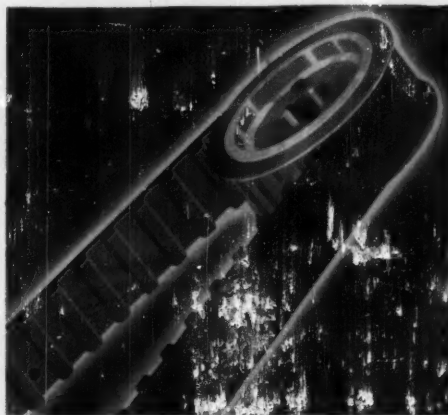
A good deal of the reason is U. S. PowerGrip "Timing"® Belts, invented and perfected by "U. S." Engineers, now in use on the majority of the new outboard motors. PowerGrip gives a positive, non-slip drive. It assures constant electrical output without chance of slip-up—generator performs perfectly always.

Other advantages that make PowerGrip indispensable:

- Trouble-free — no lubrication, noiseless, corrosion-resistant.
- Compact—short center-to-center distance, light weight.
- Safer—no slip to wear out belt, or cause breakdowns.

The U. S. PowerGrip "Timing" Belt drive may well improve your product, just as it has improved outboard motors. These drives are available in stock for every industry from U. S. PowerGrip "Timing" Belt Distributors, from fractional to 1000 hp.

When you think of rubber, think of your "U. S." Distributor. He's your best on-the-spot source of technical aid, quick delivery and quality industrial rubber products.



Mechanical Goods Division

United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y.

In Canada: Dominion Rubber Company, Ltd.

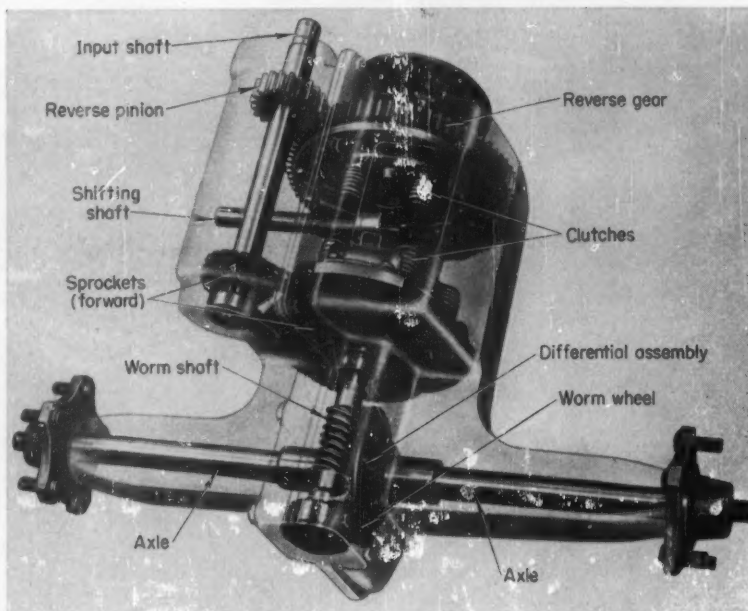
Chain and worm gear simplify a Tough Transaxle for Small Prime Movers

A NOISY FLEET of low-power vehicles keeps the average American well out of range of any hard work. Riding lawn mowers, garden tractors, golf carts, and other motorized worksavers threaten to crowd the second car out of many garages—while helping the suburbanite enjoy the rigors of land tilling. Thousands of similar vehicles—mostly for materials handling—are broken in every day by business and industry.

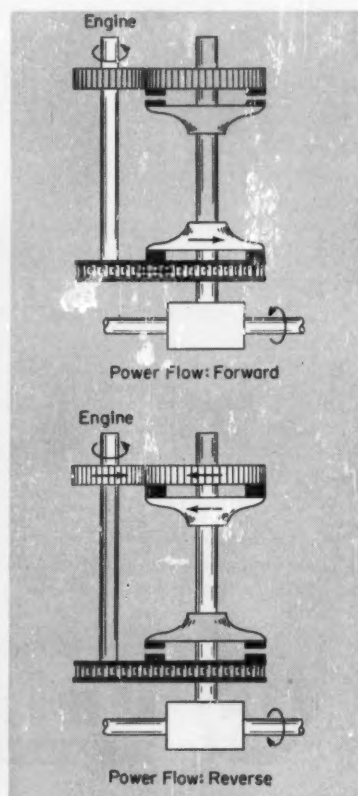
Hard pressed to keep up with the growing demand, small-vehicle manufacturers have tended to fall back on conventional designs wherever possible. But scaled-down versions of some major components haven't proved out in service. This fact is most noticeable in power-transmission equipment, according to engineers at Prime-Mover Co., Muscatine, Iowa. Dissatisfied with off-the-shelf items, P-M engineers started from scratch to design a new line of transmissions. These were the specifications:

- Maximum speed: 3 to 18 mph.
- Engine size: 7 through 18 hp.
- Axle loading: Up to 2500 lb.
- Shift: Constant mesh.
- Maintenance: No special tools or skills.

The result of their work is far

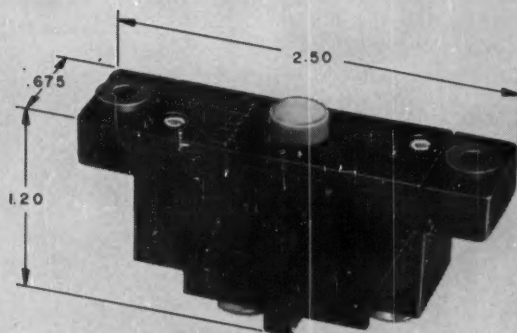


Chain and worm are key components in this small, rugged transaxle. Chain eliminates the need for a reverse idler; the worm set replaces numerous reduction gears. Forward or reverse power flow (right) is determined by two clutches—gears, bearing mounted, are always in mesh. Baggage cart (below) represents a typical application. Prime-Mover Co., Muscatine, Iowa, designed both the axle and cart.

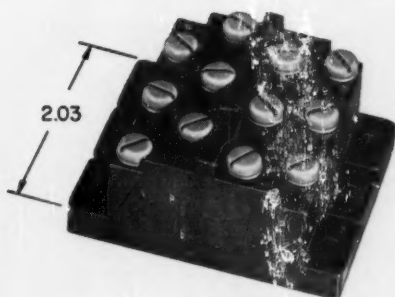




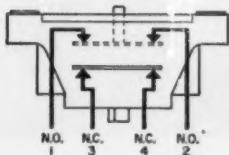
MICRO SWITCH Precision Switches



New "3MN" Series switches for machine tool controls



Bottom view of three switches shows compactness and staggered terminal pattern ...



Contact arrangement is single-pole two-circuit double-break. Can also be used as a single-pole double-throw switch. Underwriters' Laboratories listed for: 15 amps, 120, 240, 480 or 600 vac; $\frac{1}{2}$ hp, 120 vac; 1 hp, 240 vac; .8 amp, 115 vdc; .4 amp, 230 vdc. Pilot duty rating: 600 vac, max.

For complete information on these "3MN" switches contact your nearest MICRO SWITCH branch office, or send for Data Sheet 164.

... STACK IN SMALL SPACE

Step design case is only .675 in. wide. Three switches have combined stacking width of just over 2 inches.

... INTEGRAL TERMINALS

Terminal arrangement permits gang mounting without insulating barriers. The #8 terminal screws have captive lockwashers.

... LONG MECHANICAL LIFE

Median mechanical life is over 10,000,000 operations at full overtravel.

... PLENTY OF OVERTRAVEL

Overtravel is .080 in. min.

... EASILY MOUNTED

One mounting hole is elongated to eliminate the need for close tolerance in the center-to-center distance between mounting holes on the equipment.

MICRO SWITCH ... FREEPORT, ILLINOIS

A division of Honeywell

In Canada: Honeywell Controls Limited, Toronto 17, Ontario



Honeywell
MICRO SWITCH Precision Switches

from conventional: It's a compact transaxle, containing a bare minimum of parts, and it's rugged, smooth, and efficient. Forward is a chain and sprocket arrangement; reverse consists merely of two constantly meshed gears, and shifting is taken care of by two spring-loaded clutches. As a finishing touch, P-M engineers equipped the transaxle with a worm final drive—a feature that has proved highly advantageous. According to W. E. Rodler, P-M's chief engineer, dynamometer tests of the transaxle show that it delivers 10 per cent more power to the wheels than a typical spur, planetary, and bevel-gear transmission. Naturally, the worm set itself is not as efficient as a single set of spur gears, but the elimination of a second reduction set, its associated bearings, etc., more than compensates for the loss. The worm set is also responsible for these mechanical advantages:

- Clutches are mounted on the

worm shaft, after the gear reduction, which means smooth engagement and long clutch life.

- Disc brake, also mounted on the worm shaft, provides a powerful means of stopping the vehicle.
- Worm set will not lock, so the vehicle can always be pushed by hand—an important feature in some applications.
- Ratios and rotational direction of worm gears can be changed easily. Thus, gear blanks are designed so that six different ratios can be cut in the same blank—a big economy factor in the manufacturing process.

Since transmission repairmen are few and far between (besides being expensive) the transaxle has been designed with ease of maintenance in mind. A large hand hole on the top permits easy clutch adjustment, and the housing is split on a vertical plane passing through the wormshaft. The right half of the case can be unbolted to expose all working parts in their normal operating position—even a backyard mechanic can figure it out.

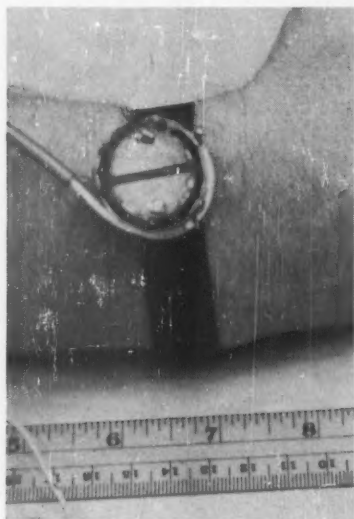
Three-Pole Magnet? Big Ten Has One

ANN ARBOR—Magnets with three poles are almost as scarce as men on the moon, but not quite. The University of Michigan says it has one. Believed to be unique, the magnet is designed for basic research on "how magnetism affects magnetic materials, which in turn affect microwaves." Specifically, its job is to "line up" crystals of magnetic materials which are used in microwave circuits.

The crystals are actually tiny magnets, but their magnetic north-south axes are not parallel to their crystalline axes. Therefore, they can't be lined up in a normal magnetic field.

The tri-polar magnet, says U-M, gets around this "discrepancy" by aligning the crystals straight up. The magnet is rotated (120 rpm) and forces of both poles are thus created all around the crystals. The path of least resistance, as far as the crystals are concerned, is up.

Ultrasonic System Measures Motions



Displacements, velocities, and accelerations in three dimensions are reported by Unopar, a device for studying human motion. Invented and patented by Gerald Nadler and Jay N. Goldman, Washington University, St. Louis, Unopar (universal operator performance analyzer and recorder) consists of a small cylindrical emitter that is strapped to the test subject's wrist, an oscillator, three microphones, and various recording instruments. Ultrasonic waves generated by the oscillator and "broadcast" by the emitter are picked up by the mikes and analyzed by the recording instruments. The microphones, when properly located,



report three-dimensional data. Unopar will find uses in industry as an aid in selecting workers and in organizing assembly lines to eliminate wasted action. The armed services are considering it as a method of gaging soldiers' movements so they can be provided with properly balanced packs. The inventors are currently doing research on the motion pattern a person develops while learning to perform a new task. Object is to reduce the time and cost required to learn an operation. Although Unopar is so far only a laboratory tool, many industrial jobs are predicted by the inventors.

TIMKEN

Fine Alloy **STEEL**



"Toughest" inspection in the steel business assures you utmost uniformity in Timken® forging steels

You can always be sure your forged products made from Timken® steel forging bars will have uniform quality. One big reason is the rigid, 100% Final Inspection we give every bar. Examination is so thorough that our Inspection Department is known as the toughest in the steel business.

You save money, too, because of the uniform quality of Timken steel. It is remarkably uniform in structure, chemistry and dimension from heat to heat, bar to bar, order to order. And because we handle each order individually, we can target our procedures to *your* end-use requirements. You don't have to interrupt your operations to make costly equipment adjustments.

Important to our operations is a new Metallurgical

Research Center, one of industry's most modern. Its facilities range all the way from an experimental melting laboratory to one of the industry's finest technical libraries. It is designed not only to improve our own products but also to solve customer problems—your problems.

When you buy Timken steel you get: 1) Quality that's uniform from heat to heat, bar to bar, order to order. 2) Service from the experts in specialty steels. 3) Over 40 years experience in solving tough steel problems.

For the most from your modern forging operations, specify Timken steel forging bars. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

TIMKEN ALLOY STEEL AND SEAMLESS TUBING ARE AVAILABLE FROM WAREHOUSE STOCKS IN 44 CITIES IN THE UNITED STATES

Disappearing Teflon May Cool Returning Space Vehicles

Two-Minute Heat Shield Would Cut Weight, Save Fuel

WILMINGTON, DEL. — Survival of space pioneers during high-speed rocket flight may depend on the controlled destruction of Teflon. According to a research study by E. I. duPont De Nemours & Co., the plastic would ablate to dissipate heat formed when the rocket re-enters the earth's atmosphere.

A Teflon coating less than one-third inch thick would protect the vehicle's skin for at least two minutes, say Drs. John C. Siegel and Paul H. Settlege, DuPont scientists. Although boundary-layer temperatures could get as high as 12,000 F, skin temperatures would stay

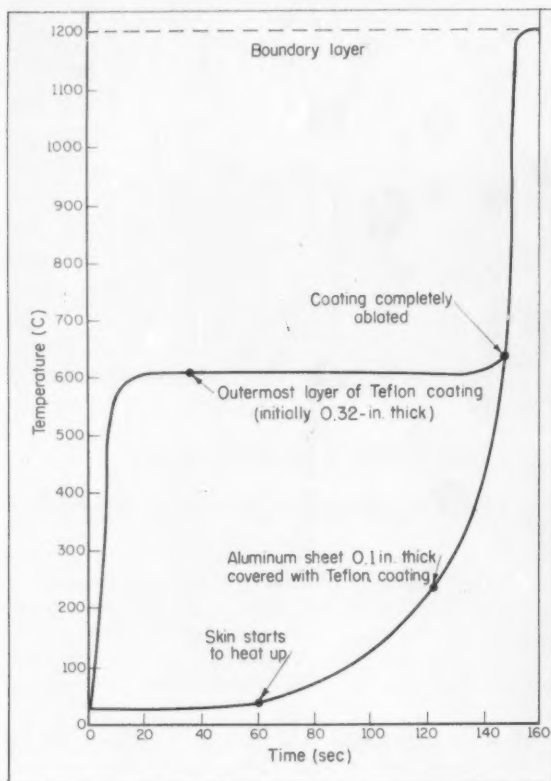
"cool enough." At extremely high temperatures, the resin turns directly into a gas. While other polymers break up in chunks, the Teflon molecule separates link by link. It absorbs a tremendous amount of heat in reverting to the gaseous raw material, and the gas, flowing back along the heated surface, helps cool the boundary layer.

The poor heat transmission of the underlying plastic limits the vapor formation to the surface area. Since heat does not cause the plastic to melt-flow, the skin retains enough strength to withstand the crushing force of the earth's atmosphere. This is essential to preserve its aerodynamic shape and to prevent a breach in the insulation wall.

No tendency to break off in small pieces, char, or crack has been observed.

Using solar furnace and plasma-jet equipment, the two scientists have been simulating conditions of outer space. They have proved that new lightweight constructions for nose cones and other space-vehicle parts are feasible. They believe that by eliminating heavy ceramic and alloy structural components and heat sinks, fuel savings of 40 pounds per pound of air-frame weight reduction are possible.

Further, inasmuch as the properties of Teflon are well known to designers, the amount of protection required can be calculated directly, rather than determined by test.



Keeping space vehicles cool as they re-enter the earth's atmosphere may be the next new job for Teflon. Teflon coatings "boil off" metal skin, taking frictional heat with them. Aluminum sheet exposed to a boundary-layer temperature of 1200 C (2192 F), but protected by a 0.32-in. thick coating, for example, stays at room temperature for one minute then rises to 620 C (1148 F) in the next 80 seconds. The coating temperature jumps up to 600-640 C (1112-1184 F) within the first few seconds. Only after the coating has ablated does the skin temperature climb



to boundary-layer temperature. Du Pont's tests (on plastic discs the size of a half-dollar) show Teflon is the most promising resin for this application. Unlike most other plastics, it converts directly to a gas, and, while ablating, it retains enough strength to preserve its aerodynamic shape and prevent a breach in the insulation wall. Du Pont's Drs. John Siegle and Paul Settlege (right) have shown that Teflon coatings less than one-third inch thick would protect space vehicles from re-entry frictional heating and would decrease capsule weight considerably.

HETHERINGTON

SWITCHES • INDICATOR LIGHTS • SPECIAL ASSEMBLIES

ENGINEERING NEWS



SOLVE SPACE AND WIRING PROBLEMS with Switch/Light Combinations

You probably use these Hetherington Switch/Light combinations every time you travel via leading air lines. Here they are used as hostess call lights. As you may have suspected, however, this is just the beginning of their usefulness—both in aircraft as well as in commercial instrumentation and control uses. Their unique combination of single- or double-pole switching action together with an illuminating push button offers definite advantages in terms of greatly reduced panel space and the elimination of switch-to-light wiring. Usually the entire assembly takes no more space than a conventional switch alone.

Circle 418 on Page 19

Of particular importance for many applications, Hetherington Switch/Light combinations make it easier for operators to keep closer tabs on crowded panels without confusing control functions. By connecting the light to an externally controlled circuit the illuminated button virtually cries, "Push Me," to attract the operator's attention at the right time. In other models, lamp circuits are controlled by the main switch contacts or by a second set of auxiliary contacts.

Typical contact ratings are 15 amps at 30 volts ac-dc. Illuminated buttons can be made in virtually any color, shape or size.

HERE'S EXTRA SAFETY FOR WARNING LIGHT APPLICATIONS

JUST "PRESS TO TEST"



Ever wonder whether a warning light for a critical circuit was merely OFF or whether the bulb was burned-out?

If so, you'll appreciate the "Press-to-Test" feature of this tiny Hetherington Type L3200 light.

The lamp and its circuit can be "checked-out" simply by pressing on the spring-mounted plastic lens cap. This makes contact through a separate third terminal circuit. When cap is released, the lamp functions through the regular circuit.

The long plastic lens of the L3200 gives wide, 180-degree visibility with either standard or edge-lit panels. Uses AN3140 lamps. For more details, write for Bulletin L-2b.

Circle 419 on Page 19

BETTER SWITCHES FOR BETTER APPLIANCES

A good electrical product deserves a good switch—and for types in the 5 to 50 ampere range that means Hetherington. Sturdy, good-looking switches—both push button, toggle, rotary, and other types—for unique operating or mounting requirements have long been a Hetherington specialty. Chances are, Hetherington switch engineers can recommend something out-of-the-ordinary that will enhance the appearance and saleability of your electrical products while assuring long, happy switch performance.

NEW PUSH BUTTON SWITCHES FOR AVIATION'S TOUGHEST JOBS . . . Designed to MIL-S-6743 Specs



Performance of these rugged, fully moistureproof snap-action switches far exceeds the requirements of MIL-S-6743, Drawing MS25089. They take a full 50G shock and 20G vibration, 5 to 2,000 cps, without chatter.

The basic switch can be fitted with any of eight different anodized aluminum mounting adapters, such as those illustrated, to meet virtually

any mounting or design requirement.

Two-circuit, three-terminal, SP-DT, and other contact arrangements are available with ratings up to 10 amps, 28 volts dc. Ask for details on Hetherington Series W100.

Similar switches for non-MIL and industrial applications are available in over 1800 different types as Hetherington Series "JR."

Circle 420 on Page 19

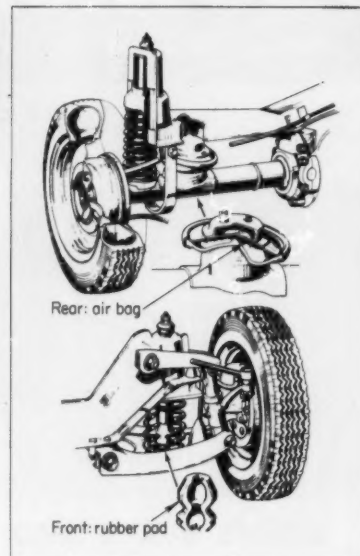
HETHERINGTON INC. DELMAR DRIVE, FOLCROFT, PA. • 139 Illinois St., El Segundo, Calif.

designed for use where one failure is one too many

Renault Gives Caravelle New Suspension



Air bags and rubber pads supplement conventional coil springs and shock absorbers in Renault's classy Caravelle. Their action gives the rear-engine (water-cooled) import virtually uniform riding qualities regardless of passenger payload. Air bags (air is contained at atmospheric pressure) augment the rear springing; rubber pads surround the front shock-absorber rods. Flexibility of these components decreases rapidly as the load increases to keep the entire suspension system "in tune" with the load. Classified a sports car, Caravelle costs \$2395.



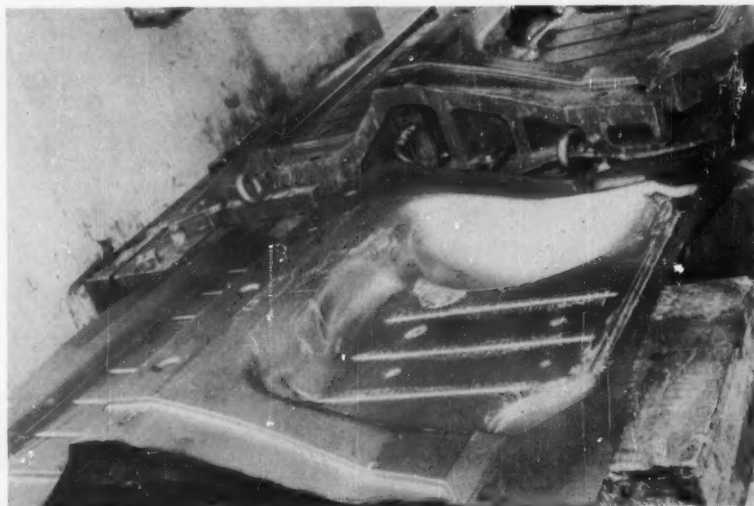
Most-Needed Inventions Listed by Armed Forces

Blue-Sky Category Includes
Brushless Motors, Cosmic Radios

WASHINGTON—Another call for help, in the form of an "inventions wanted" bulletin has been issued by the National Inventors Council on behalf of the military. The Council, an agency of the Federal Government (U. S. Dept. of Commerce, Washington 25, D. C.), periodically publishes a long list of the military's needs—which range from a more effective insecticide to an antigravity machine.

Here's a sampling of 320 problems the Army, Navy, and Air Force would like solved:

- Engine transmission and speed reducer: Light weight means for reducing speeds and transmitting high power output from turbines to propellers and rotors in turbo-prop and turboshaft aircraft engines. Present gear boxes are large, heavy and complex, and cause considerable service problems. Also in small gas-turbine engines, the gear box may make up the bulk of engine weight. A highly reliable, simple device (such as a fluid coupling) is required.
- Adhesive (for explosives): Should be capable of application without



Epoxy Dies Find Auto Uses

Ten major auto-body panels on the new Checker Motors passenger cars are drawn on epoxy resin-based dies. And although the dies are not as strong as steel, some have already drawn as many as 18,000 panels. Checker executives believe there is no limit to the number of draws possible as long as downtime can be taken for repairs and overhauls. Advantages claimed for the epoxy, compounded by Ren Plastics Inc., Lansing, Mich., include savings in labor and easier draws than are possible with steel. "For example," says a Ren spokesman, "compared to most steel dies, epoxy resin dies can go from engineering into actual production in approximately one-third less time."

use of heat in temperatures as low as -40°F and be able to hold a $2\frac{1}{2}$ -lb block of bare or packaged explosive (wrappings include water-

proof kraft paper, cotton fabric, and Saran) on a vertical surface for a period of 60 days utilizing about 15 sq in. of block surface. It should

"The difference is almost invisible."

...but it saved us nearly \$20,000"

Royal McBee had been using solid rivets and a staking machine to put together an assembly for their Royal electric typewriter. Lots of hand operations, lots of chances for scrap-making fumbles. Still, production costs were satisfactory . . . until suddenly the production rate had to be almost doubled. Costs really jumped.

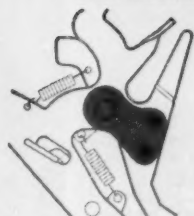
Their TRS man suggested dropping solid rivets for semi-tubular ones, automatically machine-fed and set, with a special TRS-designed loading fixture to fumble-proof the whole operation. Result: the increased number of perfect assemblies a day . . . with the same operating crew using standard TRS riveters already available at Royal McBee.

Let the TRS man look over your assemblies. You'll find that he has the viewpoint of a manufacturing engineer, and an unusual knack for making fastening simpler, faster, better.

Of course he will recommend TRS rivets. But he will give you sensible reasons why they are more reliable in essential qualities and uniformity. Superior Quality Control is one significant result of a five-year modernization of this pioneer company. Modernization of people, policies, production and service facilities. *You'll like to do business with the new TRS . . . we'll make sure of it.*

*Don't Buy Riveting Machines until you learn how the TRS **PAR** process revolutionizes riveting*

THE CHANGE THE TRS MAN MADE



OLD

Two operators assembled 2 solid rivets and 1 shouldered stud into countersunk holes of trip pawl, placed this on a tray, then placed carrier arm over stud. Third operator positioned bearing plate over rivets and stud, lifted the loose assembly from the tray and slid it under a staking machine to stake the 2 rivets.



NEW

The countersink is eliminated, in all three locations. On the special TRS sliding fixture, each operator assembles all components over 2 locating pins, with the stud in place. The loaded fixture is then slid into riveting position, and the riveter is actuated by a foot lever to fasten the assembly with 2 semi-tubular rivets.

TRS

TUBULAR RIVET & STUD COMPANY

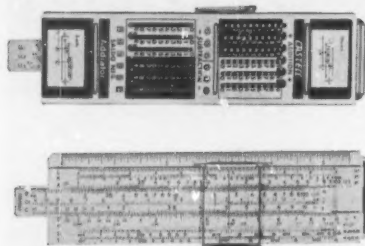
QUINCY 70, MASSACHUSETTS • TRS SALES OFFICES: Atlanta • Buffalo • Charlotte • Chicago • Cleveland • Dallas • Detroit • Hartford • Indianapolis • Los Angeles • New York • Philadelphia • Pittsfield • Quincy • St. Louis • Seattle. WAREHOUSE IN CHICAGO

See "Yellow Pages" for phone numbers.

If it's a Tubular Rivet TRS makes it . . . and Better



The World's Only SLIDE RULE- ADDING MACHINE



**On One Side, World-Famous
Faber-Castell Log-Log Slide Rule . . .
. . . and on the other, ADDIATOR,
The World's Original Precision
Pocket Adding Machine!**

Now at last a remarkable work-saving, time-saving, money-saving instrument that does all your figuring quickly and accurately, yet is not much bigger than a pocket comb and fits easily in your pocket.

Use the slide rule for lightning-fast solutions to every computing problem. It's machine engraved (markings are clear, sharp, and NEVER wipe off or wear out) . . . made of revolutionary "geroplast", a heat-proof, damp-proof plastic that can't be affected by chemicals . . . resists temperature changes, guarantees permanency and utmost accuracy even under extreme laboratory or field conditions.

Then to add or subtract to 999,999 in just seconds, simply turn the machine over and use ADDIATOR, the original world's smallest adding machine. Use it to add everything . . . columns of figures, problems, scores, business expenses, grocery tapes, budgets, bank statements, etc. Made of lifetime aluminum and brass.

AMAZING NO RISK TRIAL OFFER

Try this remarkable complete calculator at no risk. You'll find it handy, useful, timesaving. Only \$9.95 for 5" Model, complete with detailed instruction book and beautiful green leather carrying case—substantially less than the price of ADDIATOR and the Slide Rule when bought separately.

See how beautiful and priceless this invention is to you. Try it for seven days. If after a week's trial you are not delighted, your entire purchase price will be refunded.

MAIL THIS NO-RISK TRIAL COUPON TODAY

Harrison Home Products, Dept. 1-MD
8 Kingsland Avenue, Harrison, N. J.

Please rush me ADDIATOR-SLIDE-RULE for 7-day No Risk trial. I will put it to every test. Then if not delighted I will return it to you for complete money back.

- ☐ SEND C.O.D. When postman comes I will pay him \$9.95 plus C.O.D. Postage.
☐ PAYMENT ENCLOSED. I save all C.O.D. and postage charges. Same money-back guarantee.

Name Title

Company

Address

City Zone State

- ☐ Send DeLuxe 10" Model, only \$18.95 including carrying case and instruction book.

Circle 422 on Page 19

ENGINEERING NEWS

adhere to steel, concrete, treated cardboard, plastic and wood surfaces which may be wet, oily, uneven, rusty, or dirty.

- In-Flight thrust measuring device for turbojet engines: Requirement—accuracy of 1 per cent.

- Center-of-gravity indicator for aircraft: Requirement—0.2 per cent MAC accuracy for testing purposes, 0.5 per cent MAC accuracy for standard equipment. Must work under both stabilized and unstabilized flight conditions.

- Device for determining zero air-speed of helicopters and convertiplanes (hovering).

- Electronic timer: Requirement—capable of measuring time intervals ranging from 0.1 microsecond to 0.999 second, with an accuracy of ± 0.0 microsecond or better. The device should be similar to units now capable of resolving to ± 0.1

microsecond over the same time interval.

- Ductile silicon—Extensive use of silicon as a structural material is limited by a lack of ductility and by high processing costs. Due to its unique properties of corrosion resistance, infrared transparency, high hardness thermal shock resistance, and inverse thermal coefficient of expansion, the development of a ductile silicon is highly desirable.
- High-rigidity, light-metal alloys: Requirement—must have Young's Modulus of Elasticity of approximately 25,000,000 psi.

Both the National Inventors Council and the various military branches take a progressive, or optimistic, viewpoint in listing their needs—they even include a "blue sky" category. A brushless dc motor would be gratefully received, for example, as would "methods to control cosmic rays for communication and navigation," and "a means of applying antigravity forces."



Powder Keeps Electrical Parts Dry

Powdered alumina has found a new job: It makes an excellent potting compound for electrical and electronic components that must be sealed against excessive humidity. With conventional asphalts or plastics, components cannot be reclaimed and repaired if they break down. With alumina, however, the seal can be broken and the powder poured out. Scientists at Bell Telephone Labs, New York, who developed the new application, list other advantages as high melting point, negligible coefficient of thermal expansion, chemical inertness, and excellent electrical insulating and heat-transfer properties. Also, it presents no fire hazards and is competitive in price with conventional potting materials.

'60 Head Counters Backed by Computers

CHICAGO—Fastest tabulation and publication of population and housing census data in U. S. history—that's the goal of the Bureau of Census in 1960. Key tools in this massive information-collecting endeavor will be Univac 1105 computers.

A total of four 1105s will be used in reducing the decennial "head count" to facts and figures next year, two at the Bureau of the Census headquarters in Washington, one in Chicago at Armour Research Foundation of Illinois Institute of Technology, and a fourth at the University of North Carolina.

Data obtained by enumerators calling on homes will be collected, processed by census districts all over the nation, sent to Jeffersonville, Ind., for microfilming, then forwarded to census headquarters in Washington. There the data will be transferred mechanically to magnetic tapes used in the Univac computers.

Complete tabulation of the basic population and housing data is expected before the end of 1960—an achievement never before accomplished. This, in turn, will result in faster publication of the 1960 census information.

Final state bulletins containing official population counts for each state and its geographic subdivisions will be ready in late December, 1960, and early 1961, a gain of many months over previous census timing.

Meetings and Shows

Jan. 20-22—

American Management Association. Conference on Utilizing Technology to be held at the Hotel Roosevelt, New York. Additional information can be obtained from AMA headquarters, 1515 Broadway, New York 36, N. Y.

Jan. 25-28—

Institute of the Aeronautical Sci-

Remember!

When you specify Mechanical Seals...

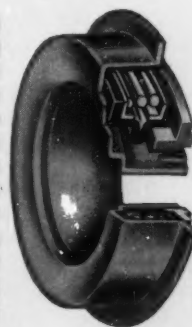
JOHN CRANE

**can supply the
exact seal
you require**



You can achieve the sealing efficiency you want . . . eliminate specification problems . . . work unhampered from drawing board to production—when you work hand-in-hand with "John Crane's" experienced engineering staff and available facilities.

Get quick, finger tip information on "John Crane's" complete line of high production mechanical seals—for every conceivable service—to meet your particular needs. Send now for illustrated technical catalog. It's yours upon request.



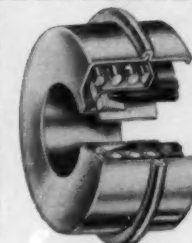
TYPE 6-A

Pressed-in packaged unit recommended for small shafts on hot or cold water, oil, gasoline or soapy liquids . . . pressures to 75 psi . . . temperatures from -65°F. to $+220^{\circ}\text{F.}$ Available in stainless steel or bronze.



TYPE 11-A

Pressed-in packaged unit with spring inside synthetic rubber bellows to protect against corrosion. For hot or cold water, oil, gasoline or soapy liquids . . . pressures to 35 psi . . . temperatures from -65°F. to $+212^{\circ}\text{F.}$



TYPE 9-A

Packaged unit with wedge sealing ring made of DuPont Teflon. Will handle practically all known industrial chemicals and corrosives . . . pressures to 150 psi . . . temperatures from -120°F. to $+500^{\circ}\text{F.}$ Supplied in metallurgical specification best suited to the service.

Crane Packing Co., 6425 Oakton St., Morton Grove, Ill. (Chicago Suburb)
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

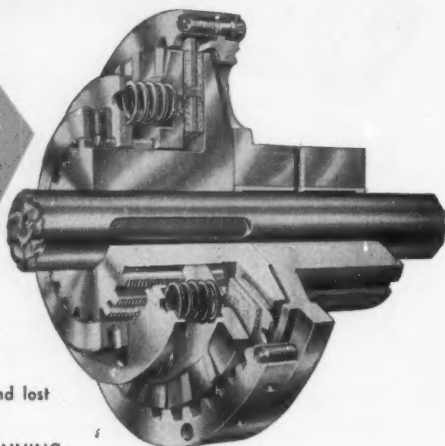
John Crane

CRANE PACKING COMPANY

HILLIARD *Clutches* FOR POWER CONTROL DESIGN

ADJUSTABLE *Slip Clutch*

- PROTECTS against overload, jams and down time.
- RESUMES THE DRIVE AUTOMATICALLY after overload.
- ELIMINATES SHEAR PINS and lost time.
- ADJUSTABLE - WHILE - RUNNING feature is available.



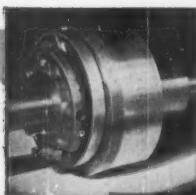
Hilliard Slip Clutches are continuously protecting the drive on dish washing machines—printing presses—packaging machines—case loaders—foundry equipment—air filters—conveyors—overhead doors—and many others. They maintain steady torque while permitting speed variation on fabric drying drums, steel strip slitters and similar equipment.

The adjustable-while-running types are used to maintain constant tension on rewind stands for paper coaters, textile machines, rope, steel and wire mills and for drive systems requiring overload protection but which must be disconnected at times.

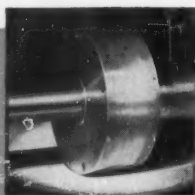
➡ WRITE TODAY FOR BULLETIN 300 WITH COMPLETE INFORMATION.

● OTHER HILLIARD CLUTCHES ●

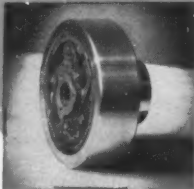
CONSIDER AUTOMATION - INVESTIGATE THESE PRODUCTS



HILLIARD - TWIFLEX CENTRIFUGAL COUPLING for smooth, easy starting of any load automatically with overload protection and ability to accommodate shaft misalignment. Ask for Bulletin CE-3.



SINGLE REVOLUTION CLUTCHES for automatic accurate control—electrical or mechanical—of intermittent motion, indexing, cycling and cut-off. Ask for Bulletin 239.



OVER-RUNNING CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet, or backstop action. Ask for Bulletin 231.

THE HILLIARD *Corporation*

MANUFACTURING CLUTCHES FOR OVER 50 YEARS

103 WEST FOURTH ST., ELMIRA, N. Y.

IN CANADA: UPTON • BRADEEN • JAMES, LTD.

ENGINEERING NEWS

ences. Annual Meeting to be held at Hotel Astor, New York. Further information is available from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Jan. 25-28—

Plant Maintenance and Engineering Conference to be held at Convention Hall, Philadelphia. (Conference dates are Jan. 25-27.) Further information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Jan. 26-27—

Society of Vacuum Coaters. Third Annual Meeting to be held at the Hotel Biltmore, New York. Technical sessions will be on Wednesday. Further information is available from John H. Smith, Application Engineer, Technical Services Dept., Consolidated Electrodynamics Corp., 1775 Mt. Read Blvd., Rochester 3, N. Y.

Jan. 31-Feb. 5—

American Institute of Electrical Engineers. Winter General Meeting to be held in New York. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Feb. 1-4—

American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc. Semiannual Meeting to be held concurrent with the Second Southwest Heating and Air-Conditioning Exposition, which is under the auspices of ASHRAE, in Dallas. Headquarters for the society meeting will be the Baker Hotel; the exposition will be in Memorial Auditorium. Further information is available from ASHRAE, 234 Fifth Ave., New York 1, N. Y.

Feb. 1-4—

Instrument Society of America. Instrument-Automation Conference and Exhibit to be held at the Rice Hotel and Sam Houston Coliseum, Houston. Additional information is available from ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

Feb. 2-4—

Society of the Plastics Industry

Inc. Fifteenth Reinforced Plastics Div. Conference to be held at the Edgewater Beach Hotel, Chicago. Further information is available from SPI headquarters, 250 Park Ave., New York 17, N. Y.

Feb. 3-4—

Midwest Welding Conference to be held at Illinois Institute of Technology, Chicago. Sponsors are Armour Research Foundation and the Chicago section of the American Welding Society. Additional information can be obtained from Harry Schwartzbart, Supervisor of Welding Research, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

Feb. 3-5—

Institute of Radio Engineers. Winter Convention on Military Electronics to be held at the Biltmore Hotel, Los Angeles. Additional information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

Feb. 14-18—

American Institute of Mining, Metallurgical, and Petroleum Engineers. Annual Meeting to be held at the Statler-McAlpin Hotel, New York. Further information is available from AIME headquarters, 29 W. 39th St., New York 18, N. Y.

Feb. 16-18—

First National Symposium on Nondestructive Testing of Aircraft and Missile Components to be held at the Hilton Hotel, San Antonio, Tex. Sponsors are the Southwest Section of the Society for Nondestructive Testing Inc. and Southwest Research Institute. Further information is available from William E. Cory, General Chairman, Southwest Research Institute, 8500 Culebra Rd., San Antonio 6, Tex.

Feb. 17-18—

Malleable Founders Society. Fifth Technical and Operating Conference to be held at the Wade Park Manor, Cleveland. Additional information can be obtained from society headquarters, 781 Union Commerce Bldg., Cleveland 14, Ohio.

(Please turn to Page 44)

DEPENDABLE AIR POWER

*E*fficiency CAN IMPROVE THE OF YOUR PRODUCT

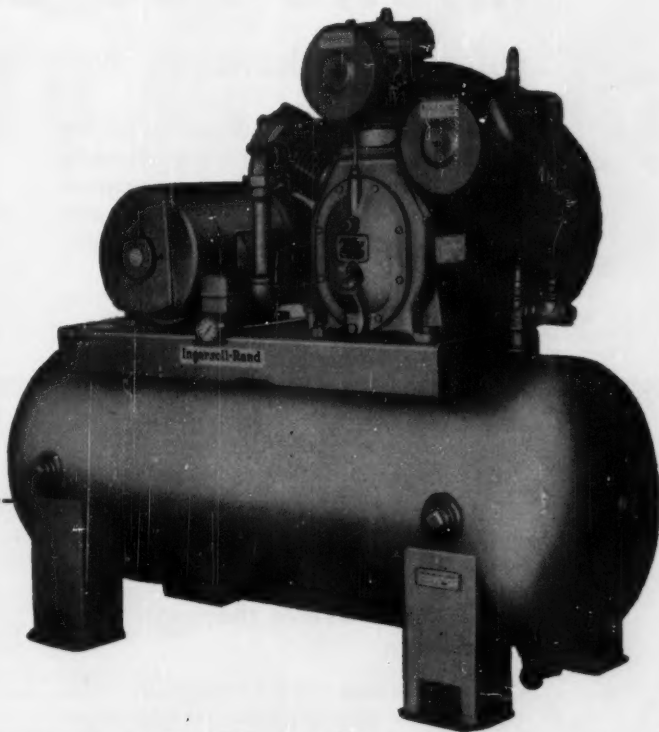
When operation of your equipment hinges on a dependable source of air, get the best compressor. It will add quality and efficiency to your product.

Year after year, since 1878, Ingersoll-Rand air compressors have set new standards of dependable operation through modern design, engineering and production facilities.

Bare, baseplate or receiver mounted air compressors can be supplied to meet your requirements.

Packaged air-cooled compressors— $\frac{1}{2}$ through 20 horsepower

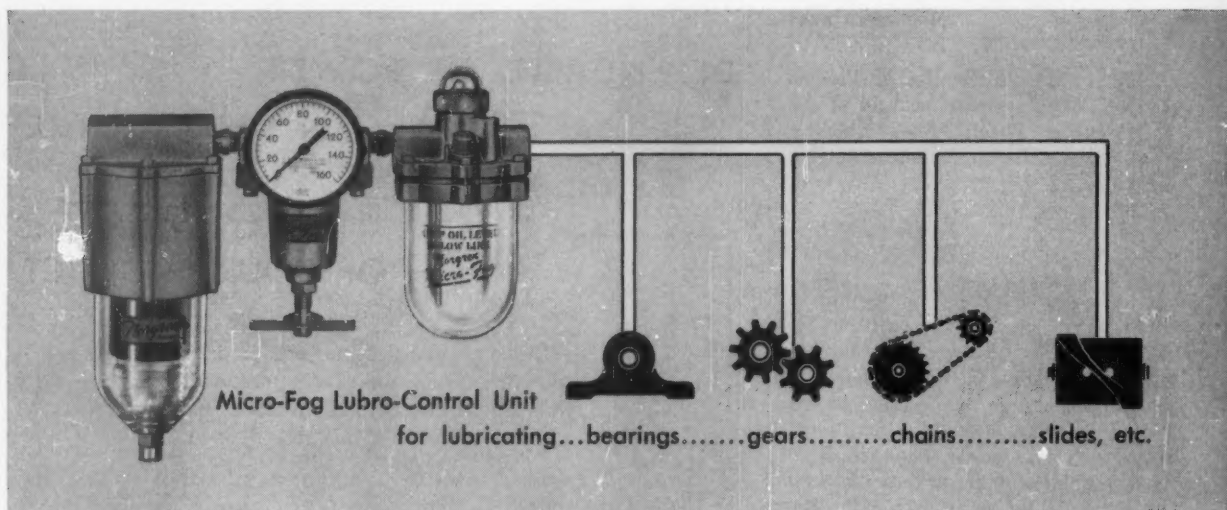
Other compressors to 6000 horsepower



Ingersoll-Rand

11 Broadway, New York 4, N.Y.

3-596



Norgren

MICRO-FOG LUBRICATION

Automatically lubricates every bearing surface on a machine

About 10 years ago, a new type of oil fog lubrication, called Micro-Fog was marketed by the C. A. Norgren Co. More and more machine tools are being completely lubricated with Micro-Fog—all bearings, gears, chains, slides, ways.

With any method of lubrication, the only oil that actually lubricates is the thin film that separates the bearing surfaces. Any additional lubricant is a waste and may even be harmful, causing overheating through fluid friction.

An air-borne fog of extremely small oil particles is created by a Norgren Micro-Fog Unit. This Norgren Micro-Fog can be conveyed long distances through low pressure pipelines directly to the bearing surfaces.

Micro-Fog provides thorough lubrication

At the bearing surfaces a nozzle-like fitting, called a reclassifier, causes the small dry oil particles to combine into larger wet particles. These impinge upon the bearing surfaces and cover them thoroughly and continuously with a protective film of oil.

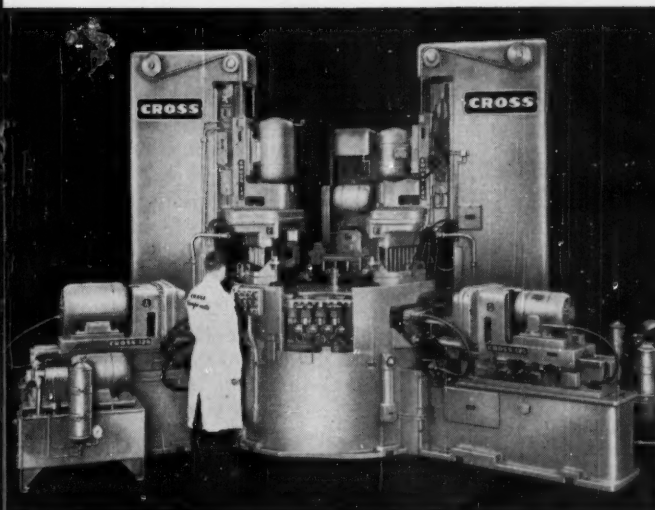
A Norgren Micro-Fog Lubro-Control Unit is a combination of three Norgren Units—an air line filter to remove the compressed air contaminants, a pressure regulator to accurately control pressure and a Micro-Fog Lubricator.

Norgren Lubro-Control Units are adjustable to deliver automatically just the right amount of Micro-Fog to provide continuous lubrication.

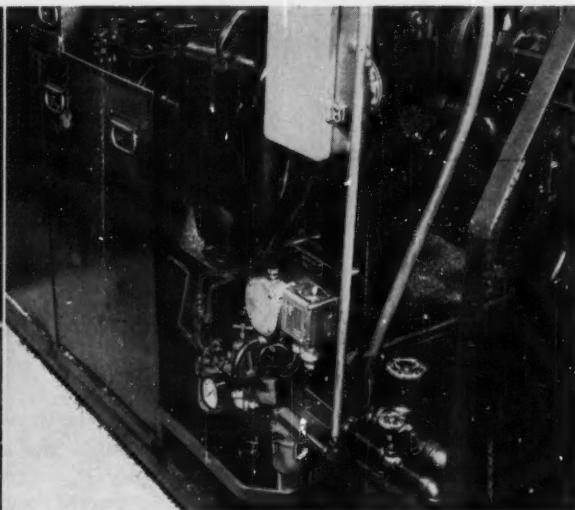
A few of the benefits provided by Micro-Fog:

Longer bearing life. Reduced downtime, maintenance and bearing replacement costs. Lower bearing temperatures. Less lubricant used—lower lubricant costs. Centralized lubrication, eliminating time-consuming hit and miss methods. No excess of lubricant—minimum product contamination and easier housekeeping.

Today, Micro-Fog Lubro-Control Units are operating successfully on practically all types of equipment. These applications range from high-speed precision grinders, running at 450,000 rpm, to huge rolling mill bearings on shafts as large as 34" in diameter and turning at relatively slow speeds.



The 150 ball bearings and 70 spur gears on this machine are lubricated by a single Norgren Micro-Fog Lubro-Control Unit. Results: 1. Bearing and gear box seals eliminated. 2. Oil leakage of lubrication system eliminated and safer floor conditions around machine. 3. Oil usage greatly reduced.

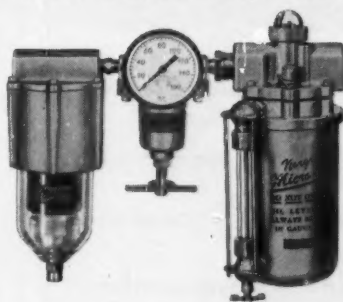


With Norgren Micro-Fog, $\frac{1}{2}$ pint of oil per day does a better job of lubrication than the 15 gallons of oil used per day with the previous circulating system. On this automatic screw machine, the Norgren Micro-Fog Unit lubricates sleeve bearings, anti-friction bearings, slide blocks, guides, chucking mechanism and gears.

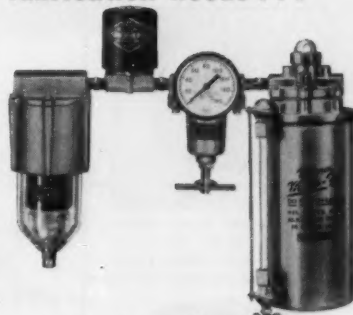
Wide selection of Norgren Units meets most machine lubrication needs . . .



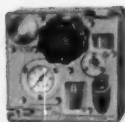
Small, compact units for use where space is tight.



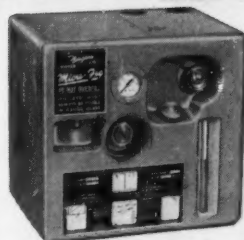
A Norgren Lubro-Control Unit can be made up of any combination of Norgren filter, regulator, lubricator.



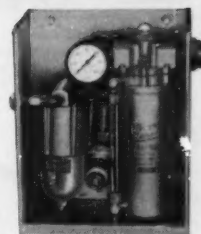
A solenoid valve for starting and stopping lubrication as machine is turned on and off can be incorporated as part of a Lubro-Control Unit.



This Lubro-Control Unit is small, compact and complete with filter, regulator and lubricator. It measures only $6\frac{1}{2}'' \times 6\frac{1}{2}'' \times 5\frac{3}{8}''$.



Compact and complete, this Norgren Unit includes automatic alarm controls that safeguard the machine against lubrication failure.



This cabinet unit can be entirely enclosed and locked. It is compact and complete and is equipped with automatic alarm controls.

The above is only a partial listing of the complete Norgren line. For complete information on the large selection of Norgren Micro-Fog Lubro-Control Units available, **WRITE FOR DESCRIPTIVE LITERATURE**

FOUNDED 1926

C. A. NORNGREN CO.
3442 SO. ELATI STREET
ENGLEWOOD, COLORADO

January 7, 1960

Circle 426 on Page 19

1602

43



SERIES 365—Controls up to 6 individual load circuits; easily changed from "Reset" to "Non-Reset."



SERIES 306—Controls 2 separate adjustable load circuits; built-in dwell protects reversing motors.



SERIES 304—Percentage Timer; integral "On Off" control eliminates separate switch.



SERIES 307—Revolution Counter; permits direct connection to flexible cables, differential couplings, gears, rotating shafts.

TIMERS FOR AUTOMATIC CONTROL

**SPLIT SECONDS OR HOURS
ACCURATE . . . RUGGED**

Now you can order off-the-shelf timers for every industrial control application, including highly complex control functions involving hundreds of timed or sequential operations. ATC offers the widest line of standard timers, plus complete design and engineering assistance to meet special requirements. These unique features mean more dollar value from ATC timers:

Easy one-hole mounting in standard

3 3/16" cut-out.



Fully insu-

lated ring clamp replaces screws.



Change cycle any time with

handy large knob.



Cover slips

off without disconnecting timer from

service.



One piece rolled cover

has integral printed wiring



schematic.

Write now for new illustrated Condensed Catalog; contains complete specifications and performance data.



AUTOMATIC TIMING & CONTROLS, INC.
KING OF PRUSSIA, PENNSYLVANIA
A SUBSIDIARY OF SAFETY INDUSTRIES, INC.

ENGINEERING NEWS

(Continued from Page 41)

Feb. 18-20—

National Society of Professional Engineers. Winter Meeting to be held at the Broadview Hotel, Wichita, Kans. Additional information can be obtained from NSPE headquarters, 2029 K St. N.W., Washington 6, D. C.

March 6-9—

American Society of Mechanical Engineers. Gas Turbine Power and Hydraulic Conference to be held at the Rice Hotel, Houston. Additional information can be obtained from ASME, 29 W. 39th St., New York 18, N. Y.

March 7-8—

Steel Founders' Society of America. Annual Meeting to be held at the Drake Hotel, Chicago. Further information can be obtained from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

March 14-18—

National Association of Corrosion Engineers. Annual Meeting to be held in Dallas. Additional information is available from NACE headquarters, 1061 M & M Bldg., Houston 2, Tex.

March 15-17—

Society of Automotive Engineers Inc. National Automobile Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

March 21-24—

Institute of Radio Engineers. National Convention and Radio Engineering Show to be held at the Waldorf Astoria Hotel and the Coliseum, New York. Further information is available from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

March 22-24—

Society of Automotive Engineers Inc. National Production Meeting to be held at the Statler Hotel, Cleveland. Further information is available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

March 29—

Material Handling Institute Inc. Spring Meeting to be held at the Pittsburgh-Hilton Hotel, Pittsburgh. Additional information can be obtained from Hanson & Shea Inc., 1 Gateway Center, Pittsburgh 22, Pa.

March 29-31—

22nd Annual American Power Conference, sponsored by Illinois Institute of Technology in co-operation with a total of 23 technical societies and educational institutions, to be held at the Hotel Sherman, Chicago. Further information is available from conference director R. A. Budenholzer, Mechanical Engineering Dept., Illinois Institute of Technology, 3300 Federal St., Chicago 16, Ill.

April 4-7—

American Management Association. 29th National Packaging Exposition to be held at Convention Hall, Atlantic City, N. J. The National Packaging Conference also will be held at Convention Hall, April 4-6. Further information is available from AMA headquarters, 1515 Broadway, New York 36, N. Y.

April 5-8—

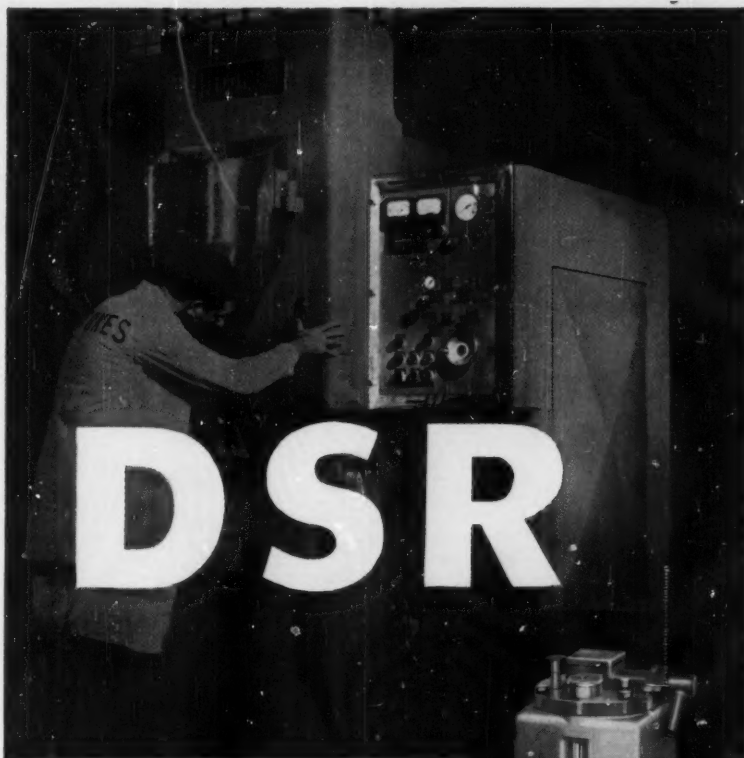
Society of Automotive Engineers Inc. National Aeronautic Meeting (including production forum and engineering display) to be held at the Hotel Commodore, New York. Further information can be obtained from society headquarters, 485 Lexington Ave., New York 17, N. Y.

April 18-19—

Third Annual Conference on Automatic Techniques to be held at the Cleveland-Sheraton Hotel, Cleveland. Additional information is available from conference publicity chairman, Room 530, 1213 W. Third St., Cleveland 13, Ohio.

April 21-28—

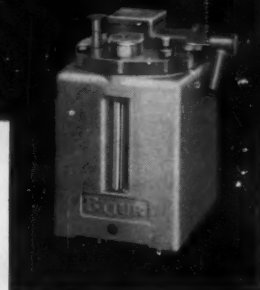
American Society of Tool Engineers. Tool Show to be held in the Artillery Armory, Detroit. Further information can be obtained from ASTE headquarters, 10700 Puritan Ave., Detroit 38, Mich.



DSR

Specify
BIJUR
AUTOMATIC LUBRICATORS

For **DSR**
DESIGN, SERVICE AND RESEARCH
are part of every Bijur System



Consider Design—All Bijur pumps are designed to be an integral part of your equipment not a cumbersome attachment. Compact modern designs permit easy adaptation, enabling operation of the pump by means of gear, belt or chain drive or independently operated by electrical or hydraulic set-ups.

How you benefit—Custom-engineered Bijur automatic lubricating systems save production time and repair bills. Down-time and fire risks are sharply reduced. Costly hand oiling is eliminated and every bearing gets the right amount of oil when needed—there's no chance of under oiling or over oiling.

Day-in, day-out Bijur Systems are proving their value to designers, plant engineers and production men on the equipment they design, use, or manufacture. Write today for all the facts about Bijur automatic lubricating systems!

BIJUR AUTOMATIC LUBRICATORS—STANDARD EQUIPMENT IN MANY INDUSTRIES

Machine Tools • Business Machines • Printing Machinery • Textile Machinery • Food Product Machines • Bottling Machines • Packaging Machines • Sheet Metal Machines • Plastic Fabricating Machinery • Glass Products Machinery • Wood-Working Machinery • Industrial Sewing Machines • Special Process Equipment



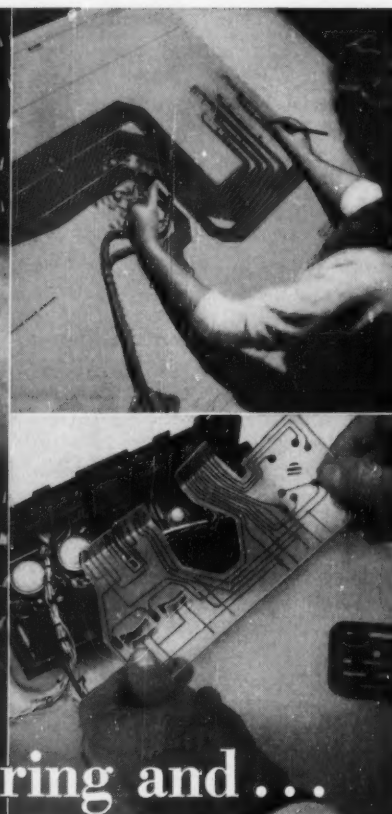
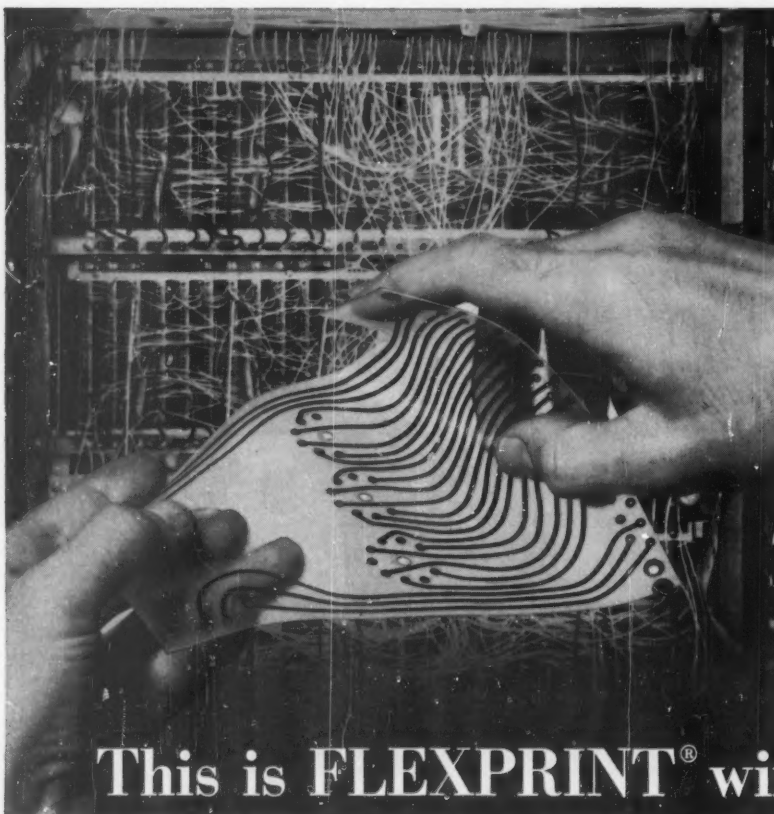
BIJUR

LUBRICATING CORPORATION

Rochelle Park, New Jersey

Pioneers in Automatic Lubrication

Ⓜ 4341



This is FLEXPRINT® wiring and...

FLEXIBLE, FULLY INSULATED PRINTED CIRCUITS offer designers of electrical and electronic assemblies new opportunities to make rewarding contributions to quality-improvement, cost-reduction and miniaturization programs.

here's how to design more reliability per dollar per pound into less space!

Whether your design objective is to upgrade wired assemblies at the lowest total installed cost or to get the utmost reliability out of the least weight or space, FLEXPRINT® wiring offers definite advantages over any other design concept.

Quality Improvement

Reliability is inherent in the unique construction of FLEXPRINT wiring. It consists of etched patterns of flat conductors permanently bonded between and to sheets of thin, flexible plastic insulation. Only the terminations are exposed . . . and they can be encapsulated if necessary. *A closer look at each construction feature tells you why FLEXPRINT wiring is more reliable* than either conventional wiring or hardboard printed circuits. All conductors maintain their positions in relation to each other. All terminations are accurately positioned. No wiring errors! No disturbing cross-coupling effects, because they're known and con-

stant. All conductors are encapsulated. No penetration of moisture and gases! Each circuit is flexible. No short or open circuits due to vibration and shock.

Cost Reduction

If cost-reduction is your goal, FLEXPRINT wiring wipes out any initial cost advantage of conventional wiring by economies all along the line. As a result, total savings in wiring costs as high as 50% can often be realized. Let's see why.

FLEXPRINT wiring comes ready for attachment. No selecting color-coded wires in assorted sizes, cutting them to length and lacing them in harnesses!

Every conductor and termination is in its right place. No wasted time and motion positioning them. Assembly time is minimum . . . as little as 1/5 th the time required for conventional wiring. Available automatic assembly and soldering techniques save additional time.

There's only one way to connect a FLEXPRINT circuit. No wiring errors! Little or no trouble-shooting. Quality control and rework costs are substantially reduced.

Miniaturization

Substantial reductions in package size and weight also stem from the unique features of FLEXPRINT wiring.

Weight reductions of as much as 50% have been obtained by switching from conventional cables and harnesses to FLEXPRINT wiring of equivalent performance.

As a space saver, FLEXPRINT wiring has no equal. Savings in the size of

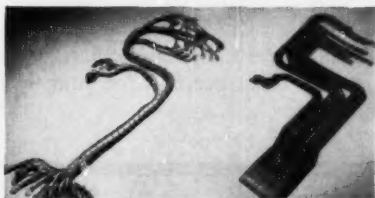
your equipment may run as high as 60%. That's because FLEXPRINT circuits can be twisted, folded, preformed and interwoven in single or multiple

layers. You make it conform to any housing geometry. With it, you can make valuable contributions to miniaturization programs.

A Question And Answer Approach To The Use Of Flexprint Wiring

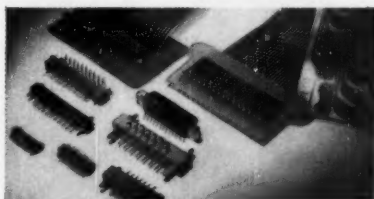
Making the transition to FLEXPRINT wiring poses no serious problems. Designers already working with hardboard printed circuits merely project their know-how into the third dimension to take advantage of flexibility and multi-plane construction. Others will find the basic knowledge and skill easy to acquire.

Fortunately, just about any question you could ask about FLEXPRINT wiring has already been asked by and answered for design engineers who are now successfully using it. Let's review a few:



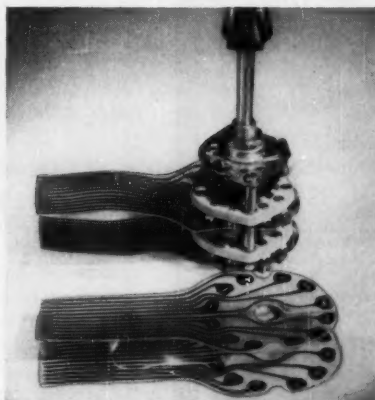
Q. Does use of FLEXPRINT wiring represent radical departures from conventional wiring routines?

A. In most respects, use of FLEXPRINT wiring involves nothing new. Through breadboard and early prototype or model stages, procedures are identical. At that point, a sketch translates wires into flat, flexible cables or harnesses. Then, it's just a drafting job to refine the pattern and produce artwork for photography and etching. Remember, at any stage, you can call on Sanders for design assistance.



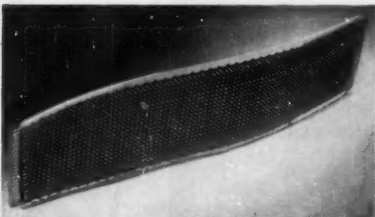
Q. Does FLEXPRINT wiring create any tough problems in terminations and connectors?

A. No! An exposed pierced pad, placed over a pin or wire and soldered with a 360° fillet, is the most common termination for FLEXPRINT wiring. Lap solder joints are also used. Termination strips, bare on both sides, are used for crimp-on connections. Many standard types of soldered and mechanical connections are available . . . and connector manufacturers are constantly creating new ones for FLEXPRINT applications. Usual considerations determine your choice of the right connector.



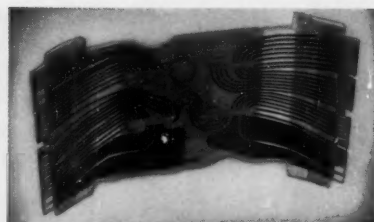
Q. What is the best way to solder FLEXPRINT wiring?

A. It depends on your particular application. Hand, dip, fountain and wave soldering may be used, as long as excessive heating of the thermoplastic insulation is avoided. Techniques employing the correct cleaning fluxes, timing and temperatures have been developed for various insulations.



Q. Can FLEXPRINT wiring be effectively shielded without depriving it of its flexibility?

A. Yes! External shielding is accomplished with adjacent layers of solid or latticed shields on one or both sides of conductors. Grounding adjacent conductors in the same layers produces internal shielding. Multi-layer techniques provide for twisted pairs and triplets.



Q. Can FLEXPRINT wiring be reinforced to add rigidity or meet environmental requirements?

A. Three methods are used to reinforce FLEXPRINT wiring: building up its insulation to add any degree of rigidity or thickness to any section; bonding glass cloth to its surface or molding it into its insulation; bonding FLEXPRINT wiring to such solid base materials as phenolic or epoxy glass . . . usually to replace combinations of printed hardboard and interconnecting wires with single pieces of FLEXPRINT wiring.

Q. Will lead time for delivery of FLEXPRINT wiring cause production delays?

A. No! Sanders production capacity is geared to match deliveries to your demands.

Q. How do I get started with FLEXPRINT wiring?

A. Your first step is to read the new bulletin, a "Designer's Digest," just off the press. It reviews several circuit design examples, shows other circuits now in use, lists new and tested applications and tells you just how to make the rewarding switch to modern flexible printed circuits.



For your copy, write:

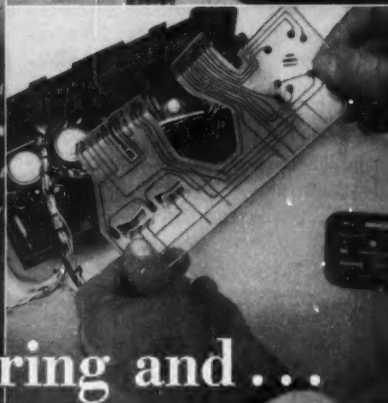
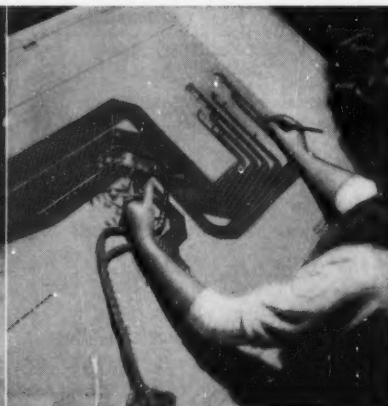
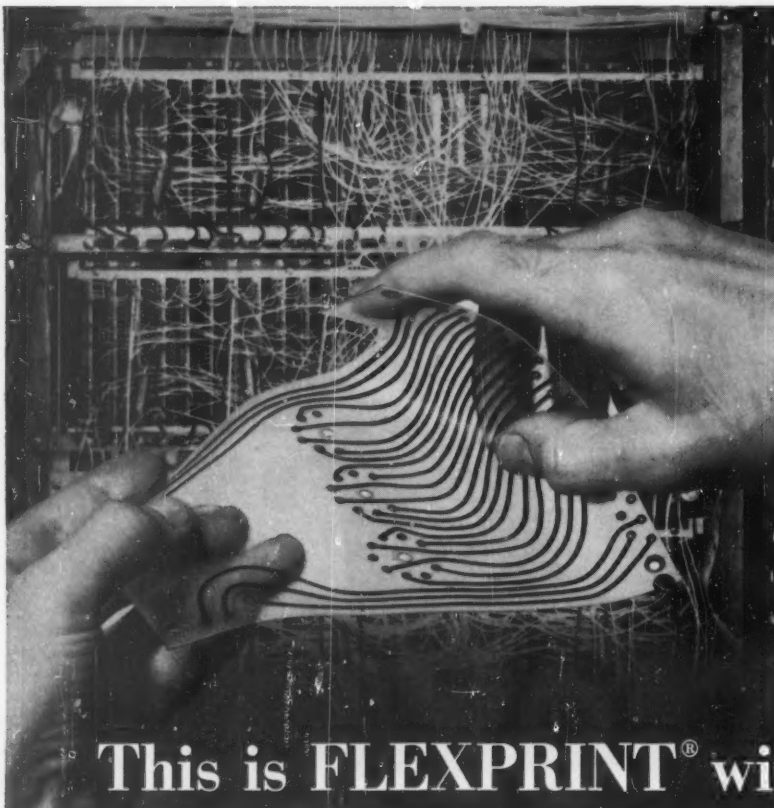


© SANDERS ASSOCIATES, INC.

PRODUCTS DIVISION

SANDERS ASSOCIATES, INC.

95 CANAL STREET
NASHUA, NEW HAMPSHIRE
TUXedo 3-3321



This is FLEXPRINT® wiring and ...

FLEXIBLE, FULLY INSULATED PRINTED CIRCUITS offer designers of electrical and electronic assemblies new opportunities to make rewarding contributions to quality-improvement, cost-reduction and miniaturization programs.

here's how to design more reliability per dollar per pound into less space!

Whether your design objective is to upgrade wired assemblies at the lowest total installed cost or to get the utmost reliability out of the least weight or space, FLEXPRINT® wiring offers definite advantages over any other design concept.

Quality Improvement

Reliability is inherent in the unique construction of FLEXPRINT wiring. It consists of etched patterns of flat conductors permanently bonded between and to sheets of thin, flexible plastic insulation. Only the terminations are exposed . . . and they can be encapsulated if necessary. *A closer look at each construction feature tells you why FLEXPRINT wiring is more reliable than either conventional wiring or hardboard printed circuits.* All conductors maintain their positions in relation to each other. All terminations are accurately positioned. No wiring errors! No disturbing cross-coupling effects, because they're known and con-

stant. All conductors are encapsulated. No penetration of moisture and gases! Each circuit is flexible. No short or open circuits due to vibration and shock.

Cost Reduction

If cost-reduction is your goal, FLEXPRINT wiring wipes out any initial cost advantage of conventional wiring by economies all along the line. As a result, total savings in wiring costs as high as 50% can often be realized. Let's see why.

FLEXPRINT wiring comes ready for attachment. No selecting color-coded wires in assorted sizes, cutting them to length and lacing them in harnesses!

Every conductor and termination is in its right place. No wasted time and motion positioning them. Assembly time is minimum . . . as little as 1/5 th the time required for conventional wiring. Available automatic assembly and soldering techniques save additional time.

There's only one way to connect a FLEXPRINT circuit. No wiring errors! Little or no trouble-shooting. Quality control and rework costs are substantially reduced.

Miniaturization

Substantial reductions in package size and weight also stem from the unique features of FLEXPRINT wiring.

Weight reductions of as much as 50% have been obtained by switching from conventional cables and harnesses to FLEXPRINT wiring of equivalent performance.

As a space saver, FLEXPRINT wiring has no equal. Savings in the size of

your equipment may run as high as 60%. That's because FLEXPRINT circuits can be twisted, folded, preformed and interwoven in single or multiple

layers. You make it conform to any housing geometry. With it, you can make valuable contributions to miniaturization programs.

A Question And Answer Approach To The Use Of Flexprint Wiring

Making the transition to FLEXPRINT wiring poses no serious problems. Designers already working with hardboard printed circuits merely project their know-how into the third dimension to take advantage of flexibility and multi-plane construction. Others will find the basic knowledge and skill easy to acquire.

Fortunately, just about any question you could ask about FLEXPRINT wiring has already been asked by and answered for design engineers who are now successfully using it. Let's review a few:



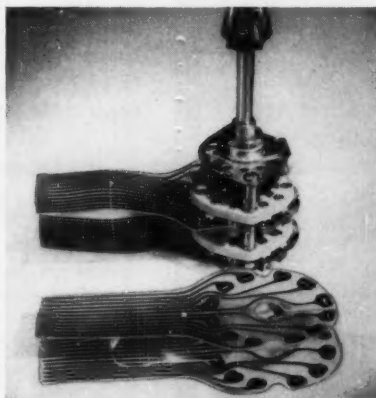
Q. Does use of FLEXPRINT wiring represent radical departures from conventional wiring routines?

A. In most respects, use of FLEXPRINT wiring involves nothing new. Through breadboard and early prototype or model stages, procedures are identical. At that point, a sketch translates wires into flat, flexible cables or harnesses. Then, it's just a drafting job to refine the pattern and produce artwork for photography and etching. Remember, at any stage, you can call on Sanders for design assistance.



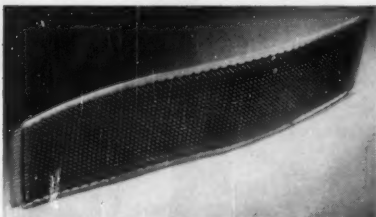
Q. Does FLEXPRINT wiring create any tough problems in terminations and connectors?

A. No! An exposed pierced pad, placed over a pin or wire and soldered with a 360° fillet, is the most common termination for FLEXPRINT wiring. Lap solder joints are also used. Termination strips, bare on both sides, are used for crimp-on connections. Many standard types of soldered and mechanical connections are available . . . and connector manufacturers are constantly creating new ones for FLEXPRINT applications. Usual considerations determine your choice of the right connector.



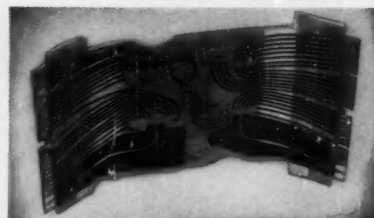
Q. What is the best way to solder FLEXPRINT wiring?

A. It depends on your particular application. Hand, dip, fountain and wave soldering may be used, as long as excessive heating of the thermoplastic insulation is avoided. Techniques employing the correct cleaning fluxes, timing and temperatures have been developed for various insulations.



Q. Can FLEXPRINT wiring be effectively shielded without depriving it of its flexibility?

A. Yes! External shielding is accomplished with adjacent layers of solid or latticed shields on one or both sides of conductors. Grounding adjacent conductors in the same layers produces internal shielding. Multi-layer techniques provide for twisted pairs and triplets.



Q. Can FLEXPRINT wiring be reinforced to add rigidity or meet environmental requirements?

A. Three methods are used to reinforce FLEXPRINT wiring: building up its insulation to add any degree of rigidity or thickness to any section; bonding glass cloth to its surface or molding it into its insulation; bonding FLEXPRINT wiring to such solid base materials as phenolic or epoxy glass . . . usually to replace combinations of printed hardboard and interconnecting wires with single pieces of FLEXPRINT wiring.

Q. Will lead time for delivery of FLEXPRINT wiring cause production delays?

A. No! Sanders production capacity is geared to match deliveries to your demands.

Q. How do I get started with FLEXPRINT wiring?

A. Your first step is to read the new bulletin, a "Designer's Digest," just off the press. It reviews several circuit design examples, shows other circuits now in use, lists new and tested applications and tells you just how to make the rewarding switch to modern flexible printed circuits.



For your copy, write:



© SANDERS ASSOCIATES, INC.

PRODUCTS DIVISION

SANDERS ASSOCIATES, INC.

95 CANAL STREET
NASHUA, NEW HAMPSHIRE
TUXedo 3-3321

IF A **MINIATURE** OR **INSTRUMENT** BEARING IS NEEDED...

NEW HAMPSHIRE

... IS THE **SOURCE!**

To meet the exacting requirements of your applications, New Hampshire maintains a full line of miniature and instrument bearings for research and development, prototypes and replacements at all regional offices. (Production quantities are shipped direct from our main plant.) NHBB sales engineers are always on call to discuss your particular needs and make specific recommendations.



RETAINER BEARINGS

This is one of the most frequently specified types for instrument applications. Available with newly designed crown retainers. This design permits even ball spacing, low torque, and most consistent performance. *Over 150 standard types and sizes are listed in our Design Manual.*

SIZES

(Available in a wide selection of combinations within the following ranges)

	BORE	O.D.	WIDTH
Min.	.0469	.1562	.0625
Max.	.3125	.6250	.1960



EXTENDED INNER RINGS ...
available on all above types

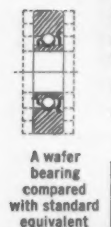


FULL BEARINGS

Specified for applications requiring maximum radial load capacity. Not suited to low torque requirements. *Over 21 standard types and sizes.*

SIZES

	BORE	O.D.	WIDTH
Min.	.0250	.1000	.0312
Max.	.3125	.5000	.1562



UP and WAFER BEARINGS

Expressly designed for use in synchros, servos, small motors, potentiometers, and gear trains. Widths are significantly narrower than standard to allow more room for rotors and stators. *Available in 16 types and sizes.*

SIZES:	BORE	O.D.	WIDTH
Min.	.0550	.1875	.047
Max.	.1875	.4375	.1094

QUALITY PERFORMANCE...

is in direct relation to quality of production. *All New Hampshire bearings* are made to ABEC-7 tolerances or better. The result is *improved running qualities* for all users... at no extra cost! In addition, rigid quality control during manufacture and continuing research enables New Hampshire to maintain leadership in our field... to supply you with the finest bearings for your needs at the lowest cost.

IMMEDIATE DELIVERIES FROM STOCK...

(For research & development, prototypes, and replacements) are made from our three regional offices as well as the main plant. Bearing specialists are on hand to help you plan and specify. Call your nearest office collect for fast service.

NEW HAMPSHIRE BALL BEARINGS, INC.

51 Cutter Mill Road
GREAT NECK, NEW YORK
Hunter 2-8633 TWX: 1421U

566 Northwest Highway
DES PLAINES, ILLINOIS
Vanderbilt 7-6646 TWX: 1642U

1540 North Highland Avenue
HOLLYWOOD 28, CALIFORNIA
Hollywood 4-0208 TWX: LA 933U

(main plant)
PETERBOROUGH, NEW HAMPSHIRE
Walnut 4-3311 TWX: 209U



NEW DESIGN MANUAL

Newly revised and expanded, this authoritative publication is a guide to designing around, specifying and purchasing of miniature and instrument ball bearings. Comprehensive general information, catalog data, and engineering bulletins are included in the 100-plus pages. A personally registered copy is available to qualified engineers, draftsmen, and purchasing departments.

For your free Design and Purchasing Manual, write or call any New Hampshire Office.

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.

Here's
the one
fan
that meets all
of today's
electronic
cooling
requirements!



... compare it with the weight of your lighter



ENGINEERS WHO THINK AHEAD... CHOOSE **MINI-SPOT** BY PESCO!

Developed by forward-looking Pesco engineers to meet advanced cooling requirements, Mini-Spot Axial Flow Fans are available from stock in limited quantities for evaluation or prototype development. These lightweight miniaturized fans provide selective cooling in confined areas... meet and exceed all applicable military specifications for shock, humidity, vibration, temperature! A self-contained package with micro-matched fan and motor produced by Pesco, Mini-Spot fans are now extensively employed in weapon systems guidance, communications and ground support equipment as well as marine and widely diversified commercial electronics applications. In addition to standard axial flow fan designs with ratings from 5 to 45,000 cfm, Pesco offers a complete design-and-build service to meet your specific requirements. Write for complete information.



PESCO PRODUCTS DIVISION
BORG-WARNER CORPORATION
24700 North Miles Road • Bedford, Ohio

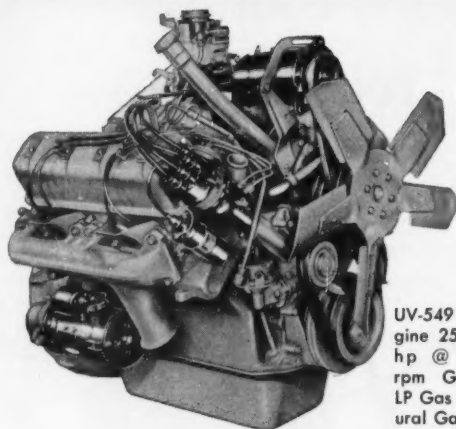
EXPORT SALES:
Borg-Warner International Corporation
36 Wabash Avenue
Chicago 3, Illinois

Major airlines around the world



prefer
HOBART
aircraft
energizers
powered by

INTERNATIONAL®



UV-549 V-8 engine 257 max. hp @ 3,400 rpm Gasoline, LP Gas or Natural Gas.



Report from
Roger Frantz,
Design Engineer,
Hobart-Motor
Generator Corp.

"Here's why we use
IH power in our
all new self-propelled
and portable 400-cycle
ground power units..."

"Wide range of power sizes available in the International line fits in with Hobart plans to offer the customer a wide selection of models to choose from.

"Rugged industrial design, incorporating the latest developments for economy and dependability, is specified for Hobart equipment. IH power meets all requirements.

"Past performance with proof of satisfactory operation is required, too. International records show millions of hours of trouble-free performance on the job.

"World-wide parts and service facilities is another one of International's strong points. We know that Hobart ground support units never sit idle waiting for IH parts and service."

When your products advance to the design stage, check into the complete International engine line —14 carbureted models, 10 diesels, from 16.8 to 385 max. hp. You'll like the one common feature of all 24 engines: fastest payback power for users. Just call or write International Harvester Co., Engine Sales Dept., Construction Equipment Division, Melrose Park, Ill.

INTERNATIONAL®
IH ENGINES

International Harvester Co., 180 N. Michigan Avenue, Chicago 1, Illinois

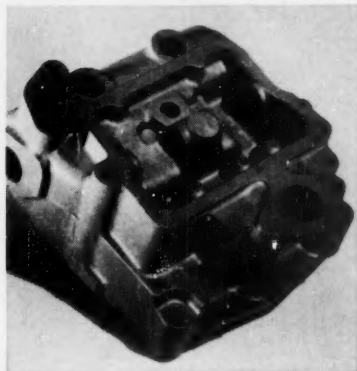
A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors... Self-Propelled Scrapers and Bottom-Dump Wagons... Crawler and Rubber-Tired Loaders... Off-Highway Haulers... Diesel and Carbureted Engines... Motor Trucks... Farm Tractors and Equipment.

PRODUCT-DESIGN BRIEFS FROM DUREZ

- Smooth surfaces in metal castings
- Plastic in luggage pods
- Fast facts on phenolics

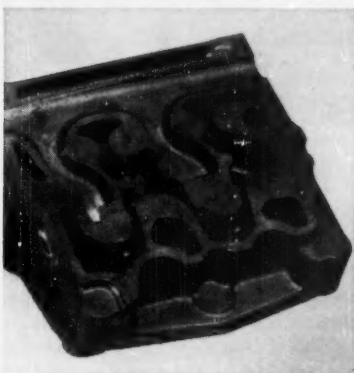
Inside story

In an engine block such as this one, smoothness of the inner surfaces is a high-priority design problem. Any obstruction or undue roughness in the channels is likely to impede the flow of coolant through the block.



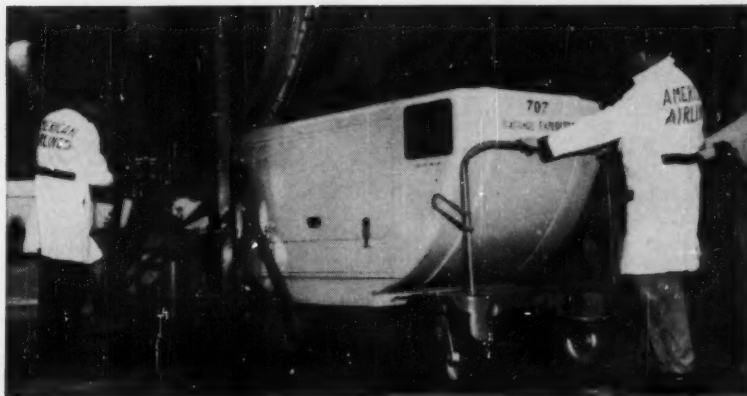
To solve the problem, more and more foundrymen are switching to a method of making castings that gives smooth, clean inner surfaces every time: shell cores.

They're getting more than smoothness. The close tolerances possible with shell cores permit holding section thickness uniform throughout the piece, and from piece to piece. In an engine block, that means better heat transfer.



Finally, most castings made with shell molds and cores need only a bare minimum of machining. That saves money.

Want to know how these better castings are made with the help of Durez foundry resins? Check the coupon and let us send you the new "Durez Guide to Shell Molding."



AMERICAN AIRLINES

It expedites

This pod shrinks time.

For people who have alighted from a jet airliner, it shortens the wait at the luggage checkout.

For the airline, it telescopes flight schedules by cutting ground time to the necessary minimum. For the men who use it to load or unload 35 suitcases at a crack, it takes much of the "lug" out of luggage.

It has to be strong, light in weight, safe. That's why it is made of Hetron® glass-reinforced polyester. Not only does Hetron match and excel the strength characteristics of other reinforced plastics; it is also inherently

and permanently self-extinguishing. The safety is chemically locked in to stay—not obtained by dilution with additives.

Many great ideas like this one are taking shape in Hetron. They include 65-foot radomes, factory skylights, large boat hulls, outboard motor shrouds, chemical ducts and blowers, transformer housings, heavy-duty switch-gear components.

If you'd like to know more about this versatile, safe material—and who can mold it into shapes for you—check the coupon for the designer's Hetron data file.

At your finger tips

Here's the quickest way we know to compare one phenolic molding material with another. Just send for the new 16-page booklet "Facts on Phenolics." It groups the most popular Durez materials by types (general-purpose, im-

pact, heat-resistant, electrical, etc.). It lists properties of the molding compounds and of molded specimens. It tells which MIL specs a compound is designed to meet. All you do is check the coupon to get a copy free.

For more information on Durez materials mentioned above, check here:

- ☐ Data file on Hetron, including list of fabricators
- ☐ "Durez Guide to Shell Molding" (36-page bulletin)
- ☐ "Facts on phenolics" (16-page booklet)

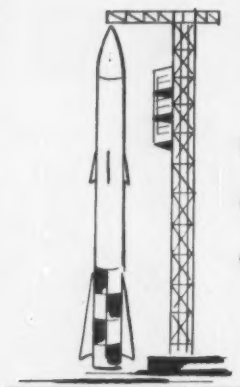
Clip and mail to us with your name, title, company address. (When requesting samples, please use business letterhead.)

DUREZ PLASTICS DIVISION

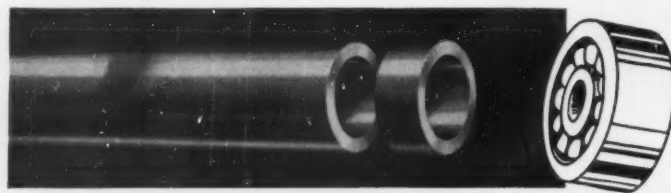
501 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOVER CHEMICAL CORPORATION



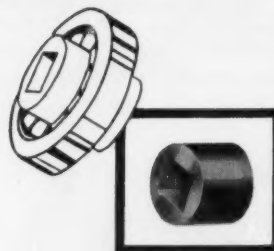


**rocket motor, or raceway—
design and fabrication
are simplified...**



WITH **ROCKRITE®** SPECIAL-FORMED TUBING

More latitude in making production *possible* at a *price*—that's your reason for using ROCKRITE. Lets you, for example, produce a rocket motor body of 4.258 inch I.D. (with $+.000$ and $-.008$ tolerance) and a .122 inch wall with a $\pm 5\%$ tolerance. Or, permits configured bores in contours other than round (see illustration, right). In SAE 52100 tubing, too, Tube Reducing is a leading supplier for high-speed production of anti-friction raceways by the ball bearing industry. Other special tubing shapes easily achieved with the ROCKRITE Process include:



SPECIAL BORE TUBING—bore shapes available: square, triangular and hexagonal, with very slight radius corners.

RIBBED TUBING—illustrates ability to work in rare metals and non symmetrical con-

figurations and eliminate machining and stock waste.

STEP-TAPERED TUBING—for structural members of wings and other highly stressed aircraft parts. Guaranteed defect-free quality.

Full details, of critical interest in solving your tubular parts problems, in Technical Bulletin SP-1.
Write for your copy today—no obligation.

T

UBE REDUCING CORPORATION

A SUBSIDIARY OF AMERICAN METAL PRODUCTS COMPANY

MAILING ADDRESS: P.O. Box 959M, Passaic, New Jersey
520 Main Avenue, Wallington, New Jersey





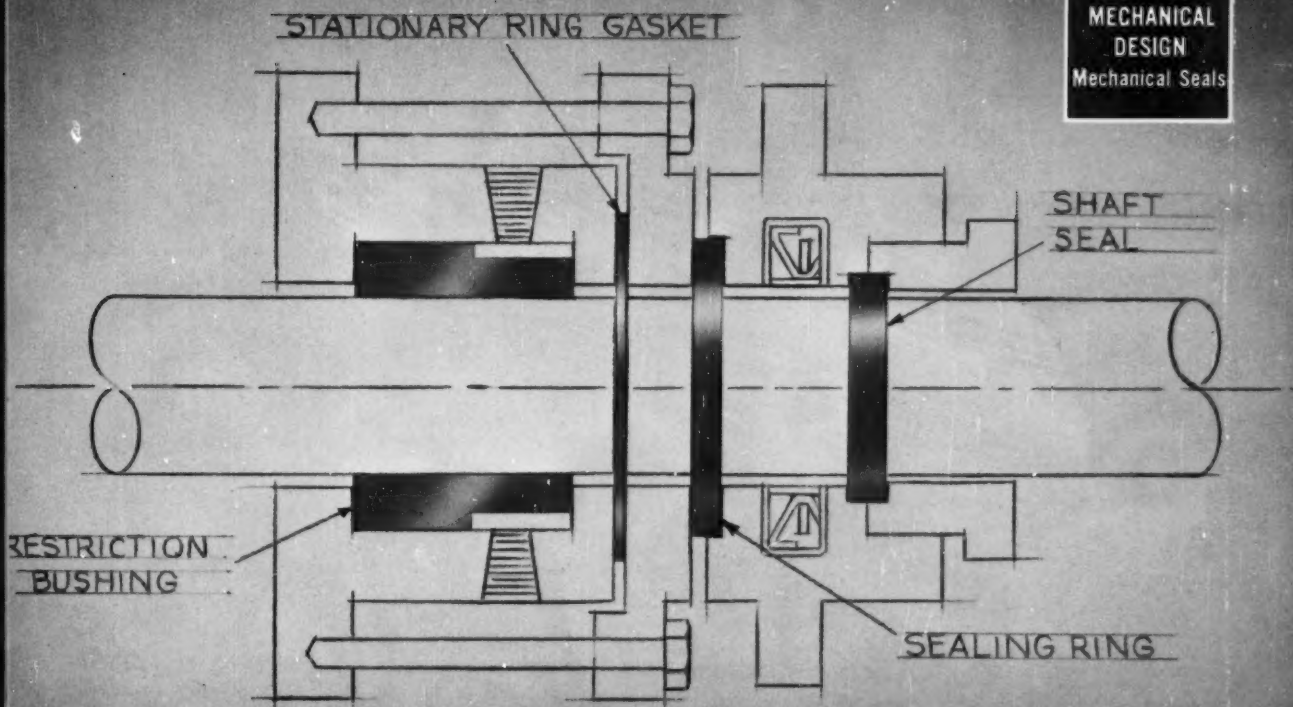
ENGINEERING FACTS ABOUT

TEFLON[®]

FLUOROCARBON RESINS

Number 1-7
in a series

MECHANICAL
DESIGN
Mechanical Seals



Here's how TFE resins improve your mechanical seals

The unique properties of TFE fluorocarbon resins as sealing materials are particularly pertinent to the design of mechanical seals. The reasons for the growing and widespread acceptance of mechanical seals as pump seals, agitator seals, motor seals and seals on many other types of moving machinery are exactly the same reasons that TFE resins are being used at the heart of the mechanical seal.

The advantages of mechanical seals include savings in both materials and labor for repacking and packing adjustment. They eliminate wear on the shaft. They greatly reduce leakage and eliminate loss of product. They enhance safety in the handling of toxic or flammable materials.

The advantages of TFE resins in mechanical seals include savings in replacement and maintenance costs because of their long life and interchangeability in being able

to handle almost all chemicals. Their natural lubricity and ability to embed hard foreign particles without damage greatly reduce shaft wear. They produce tight, lasting seals to eliminate leakage. TFE resins are completely inert to virtually all chemicals and solvents, and they maintain their superior properties under a wide temperature range.

On the following page you will see how TFE resins in the individual components of mechanical seals supplement or add to the ability of these seals to do their job in industry. When selecting a mechanical seal, it is worthwhile to remember these points.

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.

OVER

Where TEFLON TFE resins are used in mechanical seals

All mechanical seals retain the principle of two mating surfaces at right angles to the shaft. The one driven with the shaft is called the sealing ring; the other, attached to the casing, is called the gland ring. To keep the mating surfaces in contact, one or more springs may be made to bear on the movable sealing ring, or a flexible bellows or diaphragm may provide at least part of the desired spring action. Sealing of the movable ring to the shaft may be by use of a diaphragm or bellows; more commonly, the sealing ring is packed to the shaft by some form of flexible, non-metallic packing such as an O-ring, V-ring or wedge-type seal. The stationary ring is commonly sealed by means of a flexible gasket.

SHAFT SEALING

The shaft packing, a sliding seal application, makes excellent use of TEFLON TFE resins, whose chemical inertness and heat resistance make them the preferred seal material. The tremendous flex life of TFE resins also makes them excellent materials for the bellows type of shaft seal.

SEALING RING

Wear noses of compounded TEFLON TFE resins have answered the problem of extreme corrosion resistance. They will not embrittle, are easy to handle and install. Their low friction, combined with their high and low temperature properties, contributes to this application. TEFLON TFE resins have the lowest coefficient of friction of any solid material, including graphite and molybdenum disulfide. Their static coefficient of friction is even lower than the dynamic value (as low as 0.016)—completely eliminating problems of stick-slip.

STATIONARY RING GASKET

The stationary ring is frequently seated by a retaining flange with gaskets. Since TEFLON TFE resins are superior gasket materials, they have found wide acceptance in this use. In addition, TFE resins are often specified because of their interchangeability, minimizing spare-part storage.

RESTRICTION BUSHINGS

Restriction bushings are widely used with seals that are flushed to achieve cooler operation or to prevent abrasives from entering the seal. Because of their wide range of excellent properties, TEFLON TFE resins have almost become standard for this application. Aside from their chemical and thermal properties, their low-frictional characteristic means that as shaft run-out becomes a problem, the resin will not score the shaft. In addition, the anti-stick property of TFE resins prevents scale from building up on the surface.

FOR MORE INFORMATION...

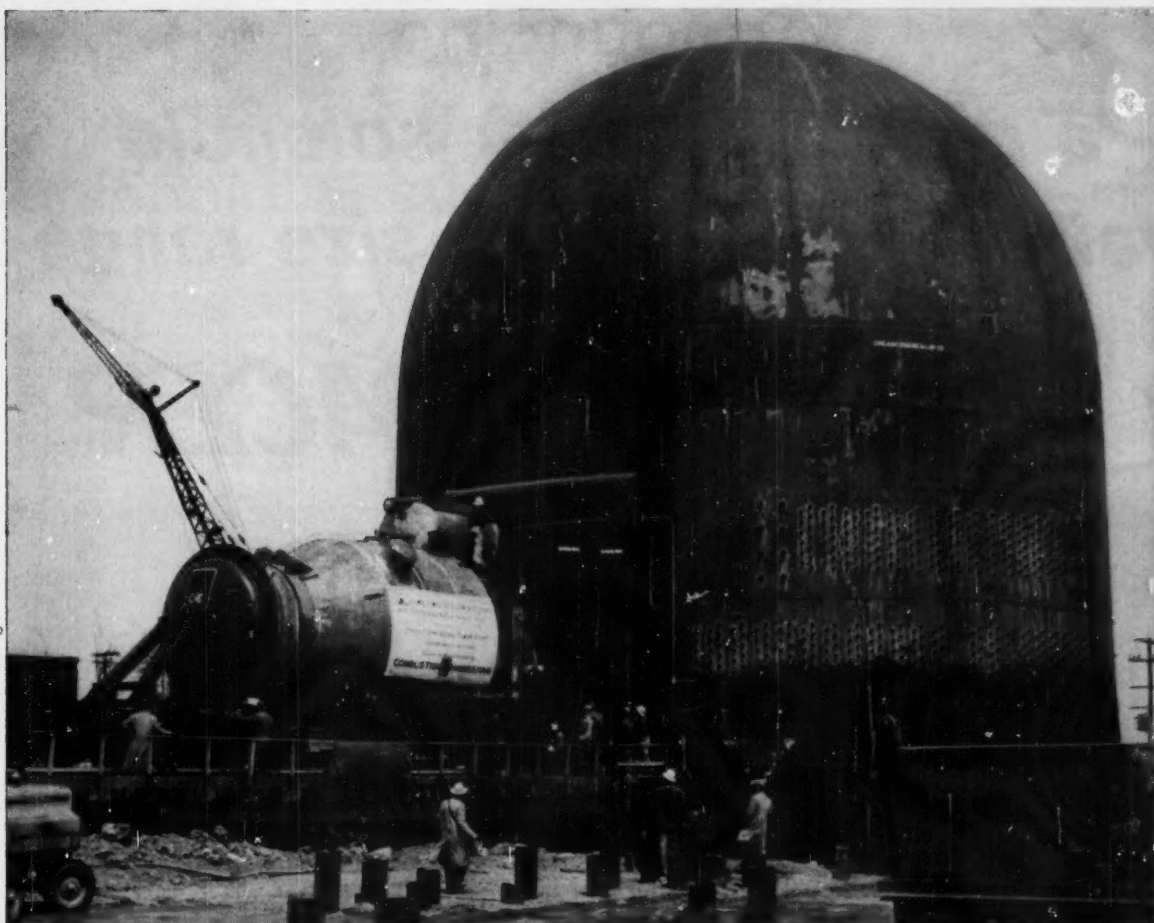
Further details on the properties and design characteristics of TFE resins for use in mechanical seals may be obtained from your local supplier. Look for him under "Plastics—Du Pont" in the Yellow Pages. Or write to: E. I. du Pont de Nemours & Co. (Inc.), Advertising Department, Room T-25160, Nemours Building, Wilmington 98, Delaware.

In Canada: Du Pont of Canada Ltd., P.O. Box 660, Montreal, Quebec.



TEFLON[®]
TFE-FLUOROCARBON RESINS

BETTER THINGS FOR BETTER LIVING... THROUGH CHEMISTRY



Atoms for Peace. This dome houses the 91-ton reactor vessel made of nickel-containing stainless steel for the new Enrico Fermi Atomic Power Plant on the shore of Lake Erie near Monroe, Michigan. Detail design and construction of the reactor vessel was done by Combustion Engineering, Inc. Plant will be built and operated by Power Reactor Development Company from designs supplied by Atomic Power Development Associates, Inc.

struction of the reactor vessel was done by Combustion Engineering, Inc. Plant will be built and operated by Power Reactor Development Company from designs supplied by Atomic Power Development Associates, Inc.

Atomic reactor "breeds" its own fuel

*Stainless steel vessel must withstand
high temperatures and corrosives*

The world's largest full-scale nuclear reactor of the "fast-breeder" type is now being built. It may well answer the question:

When will atomic power be competitive with conventional methods of producing electric power?

As the term "fast-breeder" indicates, the atom-splitting process is maintained by so-called fast or high-energy particles. It produces more nuclear fuel than it consumes. The fast-breeder actually turns out a kilogram and a fifth of new fuel for

each kilogram it burns up!


The "breeding" takes place in a 36-foot high pressure vessel. Here, the high-energy particles (neutrons) travel at speeds of thousands of miles per second to keep the atom-splitting chain reaction going.

Accent on safety. A major objective was to make this reactor vessel safe. That called for a lot of highly specialized work.

It also called for a rugged metal: one capable of withstanding the tremendous heat given off in nuclear fission, and of bearing up under the temperatures and corrosives en-

countered. The final choice? Strong, corrosion-resisting Type 304 stainless steel. It's a stainless steel that contains Nickel — one of the big reasons for these superior properties.

How to "fast-breed" ideas. Problems involving reactor materials may never be a concern of yours. But you can run into metal selection problems involving corrosion, pressures, high temperatures and other destructive conditions almost any time. When you do, remember there is a good chance that a steel containing Nickel will provide the properties you want. Let us help you find out.

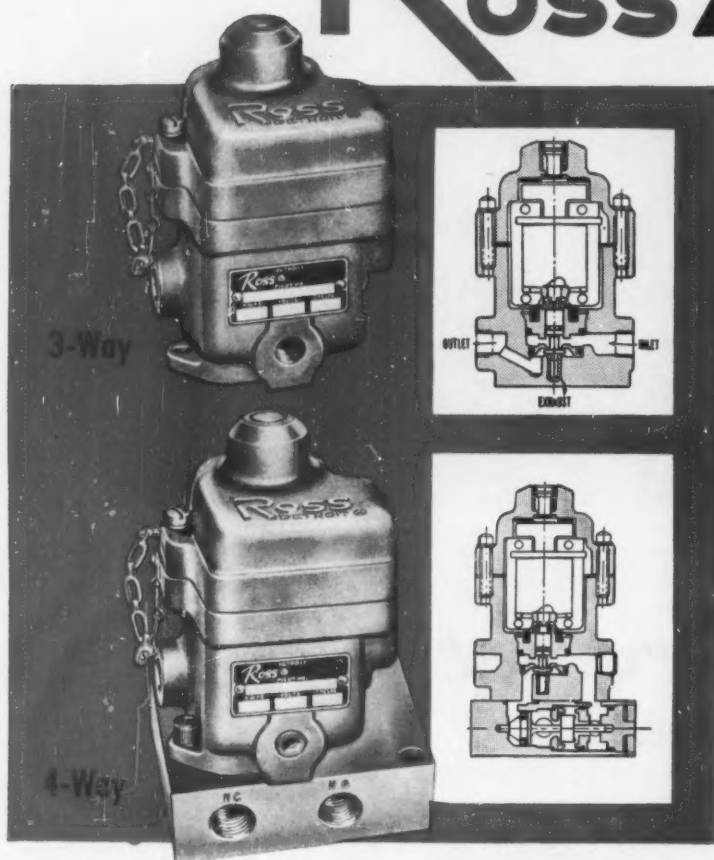
The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street  New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

Announcing a new and better solenoid valve in the $\frac{1}{8}$ " and $\frac{1}{4}$ " size range

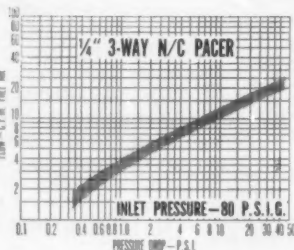
ROSS PACER



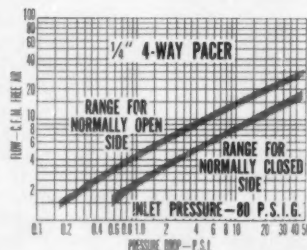
More life
More speed
More capacity
More value

Now you can have about three times more flow capacity-to-solenoid size than in most competitive valves. Needs just 7 watts of power yet minimum internal orifice size is full $\frac{3}{16}$ ". The PACER has short poppet travel, will cycle at better than 1000 cpm and meets JIC specifications. Lightweight, cast aluminum body means 3-way weighs just 20 ounces, 4-way just 28. Dust tight, liquid tight, can be manually actuated, has captive cover, is inoperative with cover removed, has integral wiring space. Why not test a PACER in your own circuit, just \$18 for a 3-way, \$26 for a PACER 4-way. Call your Ross representative or write for Bulletin 319.

Pressure drop thru 3-way N.C. Pacer valve under steady flow conditions. Inlet pressure 80 psig. Data shown as a range rather than as absolute values due to variables such as barometric pressure, manufacturing tolerances, etc.

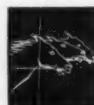


Pressure drop thru both N.C. & N.O. sides of 4-way Pacer valve under steady flow conditions. Inlet pressure 80 psig. Data shows ranges for each side rather than absolute values due to variables such as barometric pressure, manufacturing tolerances, etc.



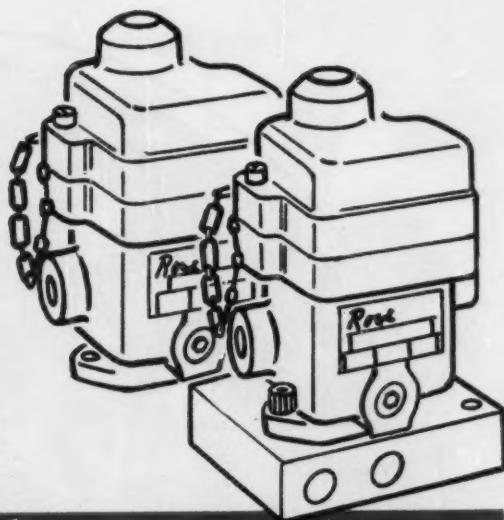
ROSS OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVE. • DETROIT 3, MICH.



The **Ross** PACER gives you 56 new solenoid air valves

The Ross PACER is a fine new solenoid valve in the $\frac{1}{8}$ " and $\frac{1}{4}$ " size range that gives a full $\frac{3}{4}$ " flow capacity yet uses only 7 watts of holding power. The PACER is built for especially long life yet is priced surprisingly low. Capable of 1000 cycles per minute and more, is JIC, and very light and compact. And if you're interested in large valves the PACER has a second identity, that of a pilot section to actuate any valve of the Ross Skyline series. It will operate any of these valves at top speed and with low power consumption.



As well as
being a
complete
new valve

...PACER is
also a new
pilot section
in the Ross
Skyline valve
series...

COMPLETE PACER VALVES

STRAIGHTWAY, N/C
3-WAY, N/C
4-WAY

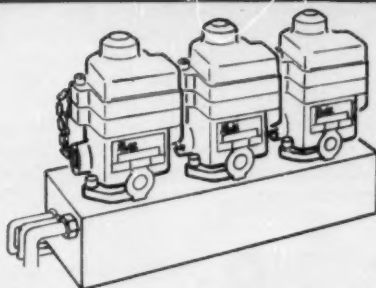
SKYLINE VALVES USING PACER AS ACTUATOR (HEAD)

STRAIGHTWAY, N/C
STRAIGHTWAY, N/O
3-WAY, N/C INLINE MT.
3-WAY N/O, INLINE MT.
3-WAY, N/C, BASE MT.
3-WAY, N/O, BASE MT.
4-WAY, INLINE MT.
4-WAY, BASE MT.
4-WAY, 5-PORT

PIPE SIZES

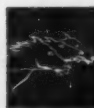
	$\frac{1}{8}$ "	$\frac{1}{4}$ "	$\frac{3}{8}$ "	$\frac{1}{2}$ "	$\frac{3}{4}$ "	1"	1 $\frac{1}{4}$ "
STRAIGHTWAY, N/C	✓	✓					
3-WAY, N/C	✓	✓					
4-WAY	✓	✓					
STRAIGHTWAY, N/C		✓	✓	✓	✓	✓	✓
STRAIGHTWAY, N/O		✓	✓	✓	✓	✓	✓
3-WAY, N/C INLINE MT.		✓	✓	✓	✓	✓	✓
3-WAY N/O, INLINE MT.		✓	✓	✓	✓	✓	✓
3-WAY, N/C, BASE MT.		✓	✓	✓	✓	✓	✓
3-WAY, N/O, BASE MT.		✓	✓	✓	✓	✓	✓
4-WAY, INLINE MT.		✓	✓	✓	✓		
4-WAY, BASE MT.		✓	✓	✓	✓	✓	✓
4-WAY, 5-PORT		✓	✓	✓	✓		

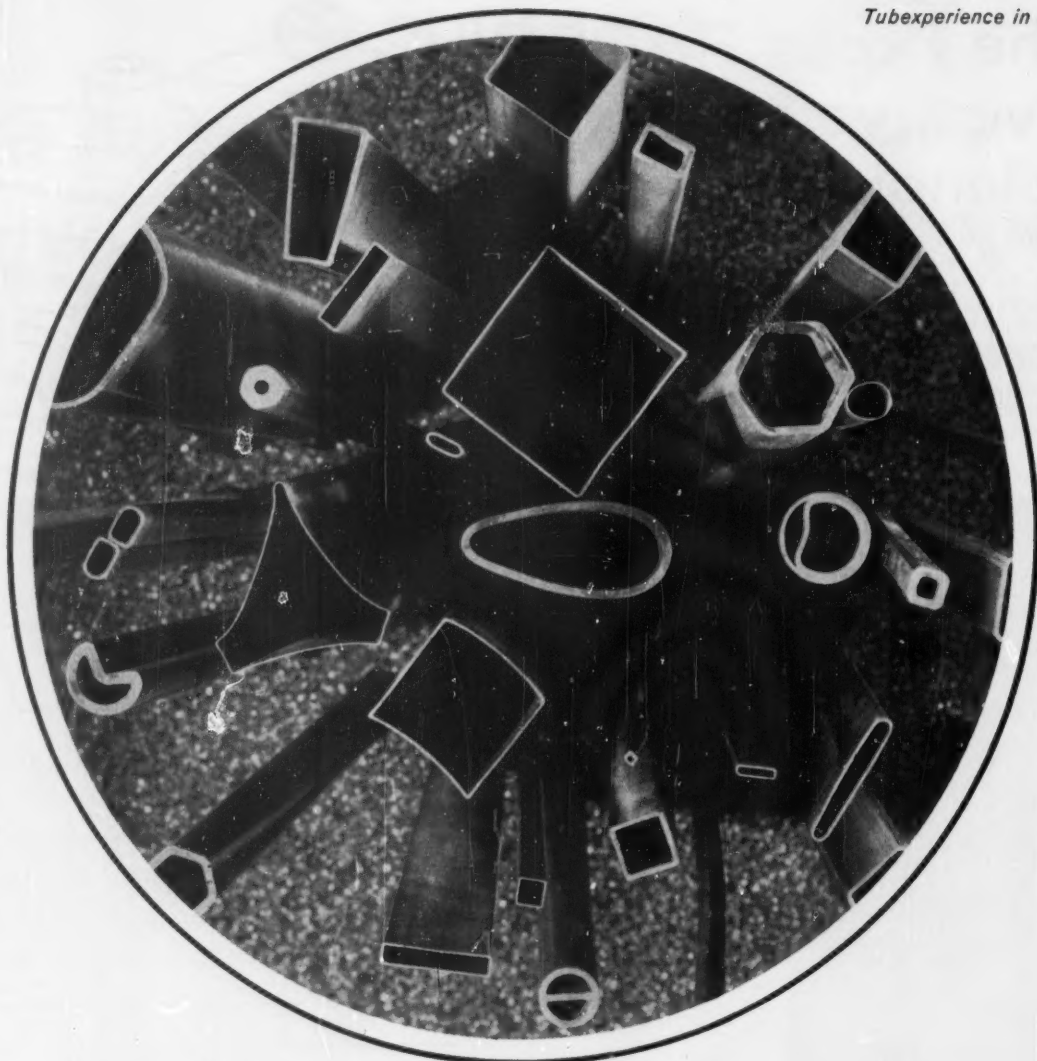
New PACER
manifolds to
save piping
and wiring



Ross manifolds provide a compact and economical method of multiple mounting PACER valves. One air supply line and one electrical conduit can serve all PACER valves. Manifolds are available in two and three stations.

ROSS OPERATING VALVE COMPANY
109 EAST GOLDEN GATE AVE. • DETROIT 3, MICH.





Tubing shaped to New Ideas

Many people think of tubing only in its most common form—round. As design engineers and buyers, you know it can be produced economically in a large variety of unusual shapes. But have you ever seen the particular shapes illustrated on this page? They are samples from production runs formed to extremely close tolerances to satisfy specific design requirements. End uses include Bourdon springs, surgical instruments, batons, aircraft structural parts, gun drill shanks, radar screens, door latches, electrical equipment, antennas, golf club shafts, fishing rods and bushings. However, we don't know where all the different shapes are used, or why they are required. But our ability to form them saves manufacturers

in many industries considerable time and money in the fabrication of their products.

Superior regularly produces shaped tubing in many analyses of stainless steel, carbon and alloy steels, nickel and nickel alloys, and glass sealing alloys. Also in titanium and beryllium copper. Shaped tubing is generally supplied in the as-formed temper (annealed before shaping), but many special tempers can be supplied.

We can probably supply your requirements at low cost, in good time. Data Memorandum No. 17 gives full details about Superior Shaped Tubing. Write for a copy today. Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing
NORRISTOWN, PA.

All analyses .010 in. to 3/8 in. OD—certain analyses in light walls up to 2 1/2 in. OD

West Coast: Pacific Tube Company, Los Angeles, California • **FIRST STEEL TUBE MILL IN THE WEST**

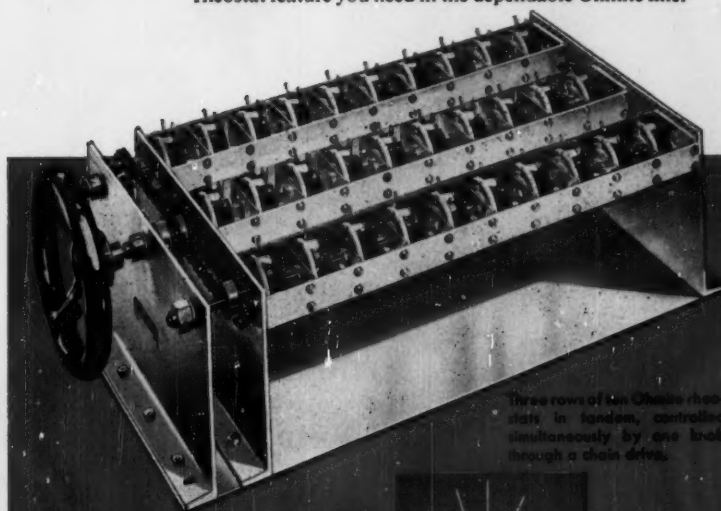
OHMITE® RHEOSTATS

WITH SPECIAL FEATURES
solve many difficult control problems

Ohmite offers not only industry's most complete line of standard rheostats but also rheostats with a wide variety of special features. Illustrated are only a few. All have the distinctive Ohmite design features: smoothly gliding metal-graphite brush; all-ceramic construction; insulated shaft and mounting; windings permanently locked in place by vitreous enamel. You will find the special rheostat feature you need in the dependable Ohmite line.

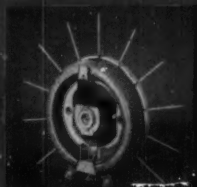


Two groups of four Ohmite taper-wound rheostats mounted in tandem, controlled by a single knob through a chain drive.



Three rows of ten Ohmite rheostats in tandem, controlled simultaneously by one knob through a chain drive.

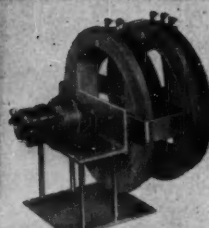
Ohmite rheostats can be mounted with two, three, or more in tandem for operation by one knob. Controls several circuits simultaneously. Model H and miniature Model E rheostats in tandem also have tandem mount.



Example of a 360° rotation rheostat with a wire lead tapered winding.



Standard type rheostat with screw driver slotted shaft.



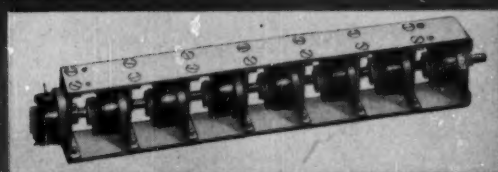
Typical Ohmite motor-driven tandem rheostat assembly.



Rheostat with tapered winding and sensitive switch, arranged to operate at any projected position of contact arm.



Ventilated cages prevent accidental injury, or human contact with electrically "live" parts.



**Call on Ohmite for
APPLICATION
ENGINEERING SERVICE**

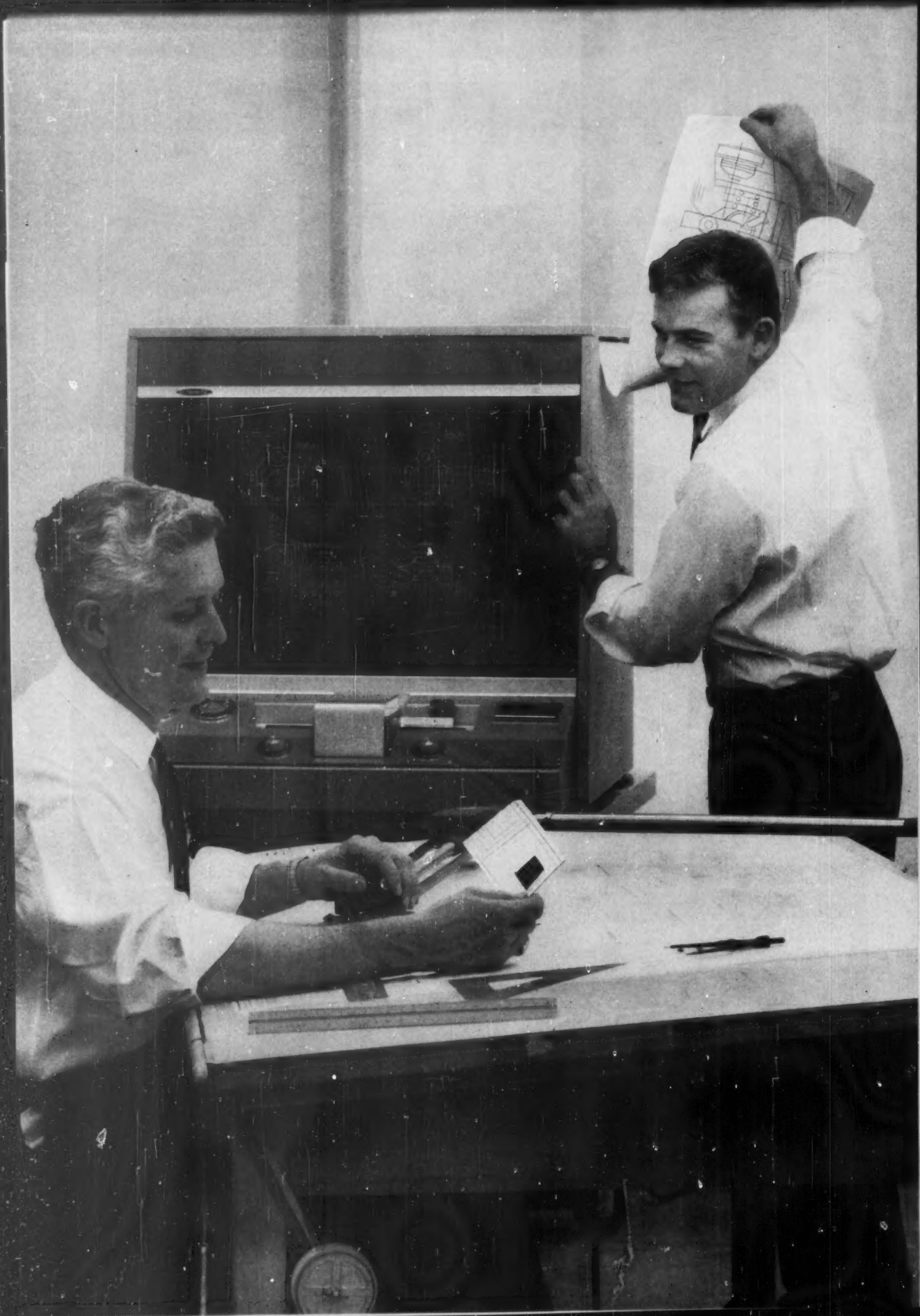
Save valuable engineering time. Team up with Ohmite to solve your resistance problems. Ohmite engineers are resistance specialists. They can quickly analyze your needs and recommend the correct rheostat to fit your application.



Write on Company Letterhead for Catalog 58.

OHMITE® Manufacturing Company
3618 Howard Street, Skokie, Illinois
Quality Components

RHEOSTATS RESISTORS TAP SWITCHES
RELAYS VARIABLE TRANSFORMERS DIODES
TANTALUM CAPACITORS R. F. CHOKES



now... 3M makes microfilm so easy to use

■ Each month more and more companies are turning to

microfilm for engineering drawing reference systems. The advantages are many—greater security plus considerable savings in manhours, materials and reproduction costs. But, the most important reason is that 3M's new THERMO-FAX "Filmac 200" Reader-Printer now makes microfilm so practical—so easy to use. ■ The "Filmac 200" Reader-Printer combines the advantages of a reader and a printer in a single low-cost unit. You can refer to the enlarged drawing clearly projected on the big viewing screen, and make a work-size print in seconds. You can take more than a look—you can take a copy. The time savings are obvious. ■ The THERMO-FAX "Filmac 200" Reader-Printer lets you make

copies of what you need when you need them. So

low in cost, it puts microfilm

in reach of even the smallest engineering firm or department. ■ If you are now using microfilm for your engineering drawings you will find that the "Filmac 200" Reader-Printer will fit into your present reproduction system perfectly. Engineers save valuable time—in seconds your reproduction department can make enlarged prints for them—or they can even make their own. ■ If you are considering microfilm for engineering drawings, investigate the "Filmac 200" Reader-Printer first. Its low initial cost and low operating cost—plus its fast and simple operation—make the microfilm reference system practical and so easy to use. ■ Call your local dealer or mail the coupon now for complete information.



THE TERM "THERMO-FAX" IS A REGISTERED TRADEMARK OF 3M COMPANY

MINNESOTA MINING AND MANUFACTURING COMPANY
St. Paul 6, Minn. **...WHERE RESEARCH IS THE KEY TO TOMORROW**

Minnesota Mining and Manufacturing Company
Dept. FBO-170, St. Paul 6, Minnesota
Please send me complete facts on the new THERMO-FAX "Filmac 200" Reader-Printer.

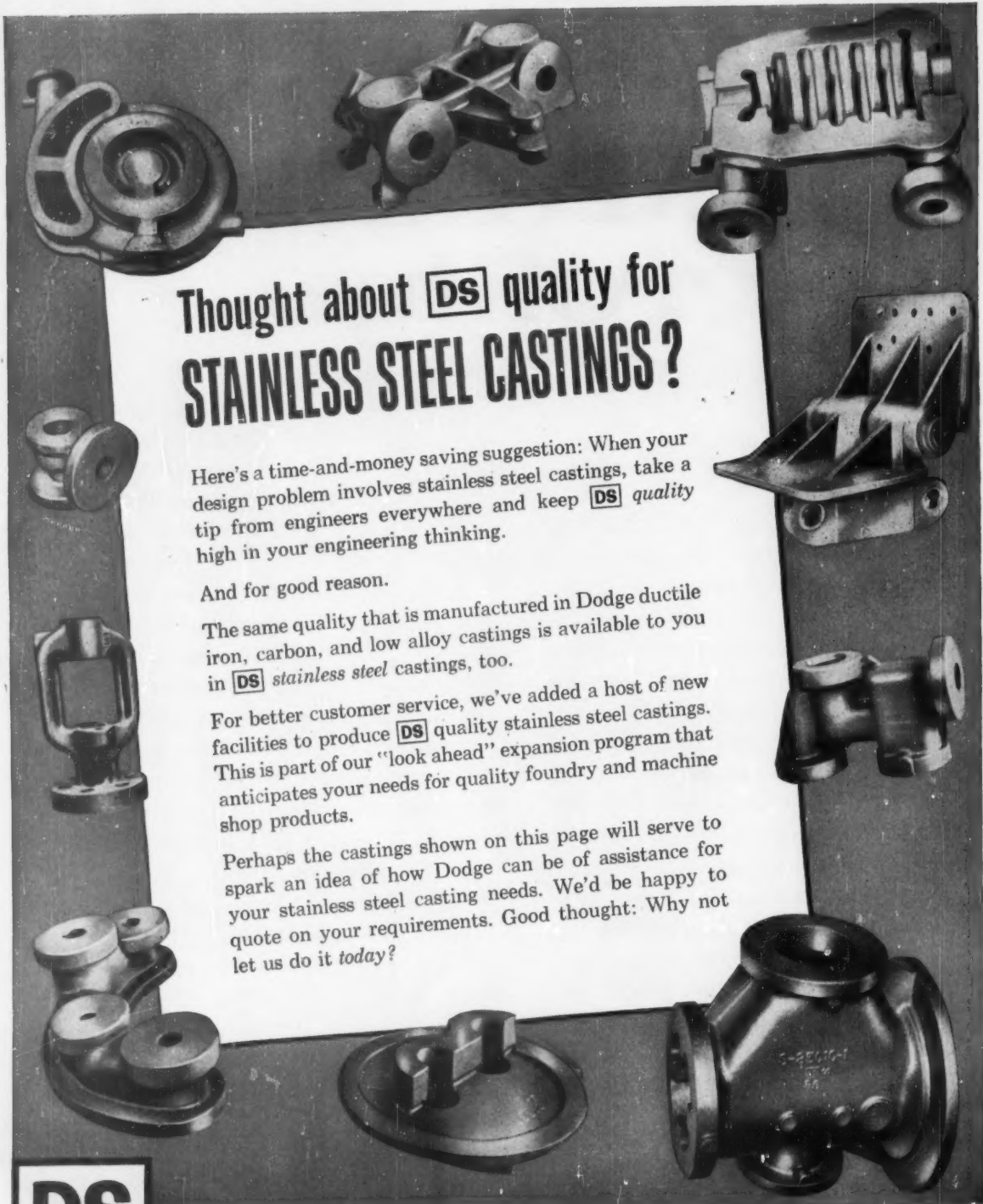
Name

Title

Company

Address

City Zone State



Thought about **DS** quality for STAINLESS STEEL CASTINGS?

Here's a time-and-money saving suggestion: When your design problem involves stainless steel castings, take a tip from engineers everywhere and keep **DS** quality high in your engineering thinking.

And for good reason.

The same quality that is manufactured in Dodge ductile iron, carbon, and low alloy castings is available to you in **DS** stainless steel castings, too.

For better customer service, we've added a host of new facilities to produce **DS** quality stainless steel castings. This is part of our "look ahead" expansion program that anticipates your needs for quality foundry and machine shop products.

Perhaps the castings shown on this page will serve to spark an idea of how Dodge can be of assistance for your stainless steel casting needs. We'd be happy to quote on your requirements. Good thought: Why not let us do it *today*?

DS

**DODGE
PRODUCTS**

DODGE STEEL COMPANY

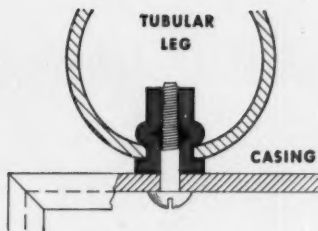
6501 State Road • Philadelphia 35, Pa. • DEvonshire 2-2200

Stainless

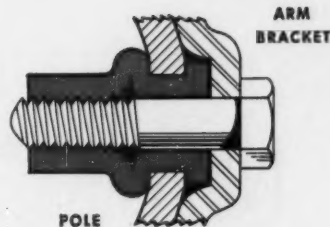
THE MOST IMPORTANT ALLOY IN A STEEL CASTING IS QUALITY

B.F. Goodrich

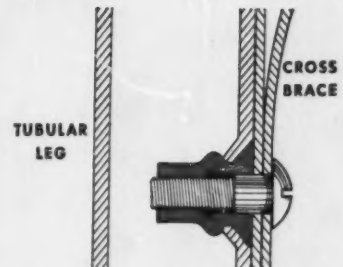
Only B.F. Goodrich Rivnuts® solve all these fastening problems so well



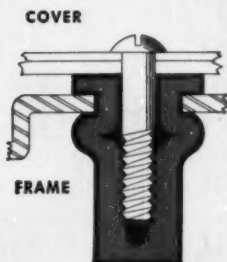
One man installs Rivnuts from one side in seconds—speeds assembly of barbecues. Permanent nutplates in legs save time in faster knockdown, too.



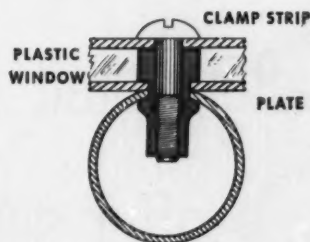
One man does the work of two, assembling arm brackets on light poles. Tests show pole or arm will fail before Rivnuts.



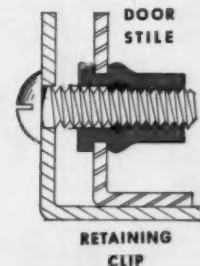
Clean, functional lines of modern furniture are preserved by Rivnuts. Upset inside tubular legs, they replace unsightly nuts, bolts and screws.



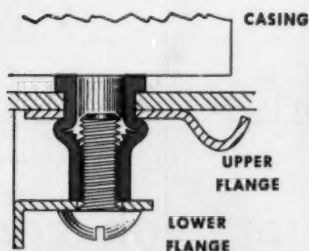
Rivnuts enable repair men to remove top of automatic washer and replace it easily. And Rivnuts can be installed after enamelling.



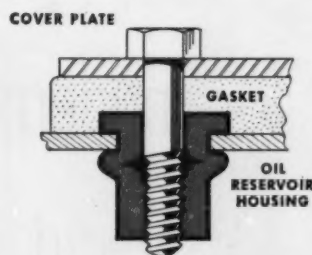
Upset Rivnuts secure airplane window plate to center post. Bulges in shanks seal out weather. Heads of Rivnuts serve as spacers for plastic window.



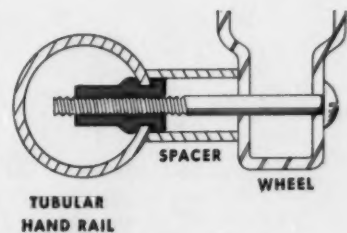
Rivnuts replace self-tapping screws used to hold retaining clips on aluminum storm doors, provide firm nutplates that won't loosen with shock or vibration.



Rivnuts eliminate need for reinforcing plates in vaporizers. In addition, Rivnuts space bottom flange automatically, preventing bending.



Assembly time for oil reservoirs is cut in half. Rivnuts eliminate welding, tapping and cleaning previously required to attach coverplate.



Wheel chair designers needed a blind nutplate with at least 6 clean threads. Rivnuts, only one-piece blind rivets with threads, were the answer.

Special fastening problems? B.F. Goodrich Rivnuts solve them. Send for free data book. Dept. MD-19.

B.F. Goodrich Aviation Products, a division of The B.F. Goodrich Company, Akron, Ohio.

B.F. Goodrich aviation products



CLARE

NEW...

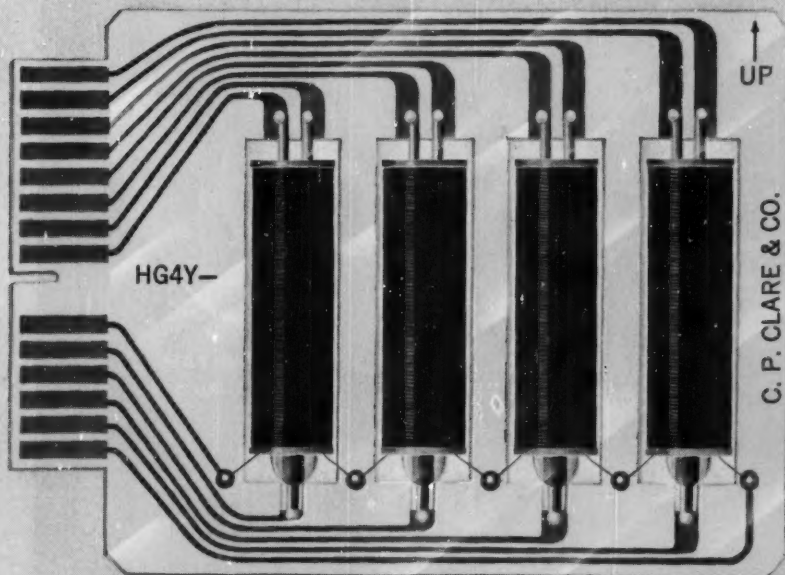
Clare printed circuit relays,
custom built to **your** design,
offer sensational savings
in space, weight, and cost
for modern data processing
and other high speed
switching devices

Relay mounted on **your** circuit board

This outstanding relay assembly permits single or multiple installation of CLARE mercury-wetted contact relays in the small space of a printed circuit board. It plugs into a console in the same manner as the logic circuit it serves.

It brings to designers of data processing and data logging equipment all the proved advantages of CLARE mercury-wetted contact relays in the smallest possible space. Individual switch capsules and coils are affixed to the printed circuit board and sealed from dust, moisture and tampering by "Skin-Pack," a tough vinyl coating.

Let us show you how we would adapt your board to include either the standard HG relay or the ultra-high speed HGS... as well as other selected components.



Typical assembly



CLARE mercury-wetted contact switch hermetically sealed in high-pressure hydrogen atmosphere. Life expectancy over a billion operations.



Each capsule is surrounded by individual coil which is custom-wound to suit the operating characteristics of the customer's application. For full information on CLARE HG printed-circuit relays send for Bulletin CPC-4.

Send us your printed circuit board

Discover how you can save time, space and money... enhance the performance of your high-speed equipment... with CLARE printed circuit relays. Contact your nearby CLARE Representative, or address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., P. O. Box 134, Downsview, Ontario.

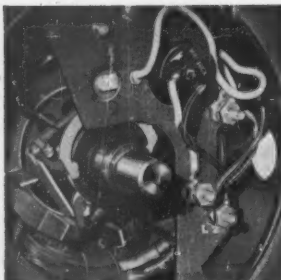
CLARE RELAYS

FIRST in the industrial field

NO STARTING PROBLEMS

with

WAGNER CAPACITOR-START MOTORS



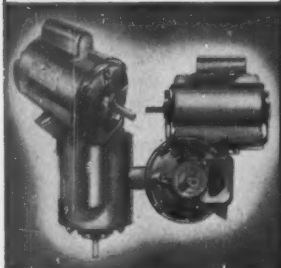
Quick Break Switch

The starting winding is disconnected from the line by this Wagner designed switch... test proved to make more than a million breaks. (That adds up to two starts per hour for 50 years!)



Quick Connect Terminals

Brass tabs on terminal studs permit quick, easy connection of leads... cut wiring time to speed assembly line production. Simply press the lead receptacle on to the stud—a positive connection is assured.



All-Angle Operation

The sleeve bearing design, in fractional hp ratings, has a positive lubrication system that permits operation in any position... can mean important savings in motor costs to manufacturers.

Pack more power into less space...give long troublefree service...are easy to hook up

Here are general purpose single-phase motors that have high starting torque and high pull-in torque. When used in the proper application and supplied with voltage close to their rating, they'll give positive starts every time. Troublefree operation is assured... thanks to the positive action of the Wagner governor mechanism and long life quick-break switch.

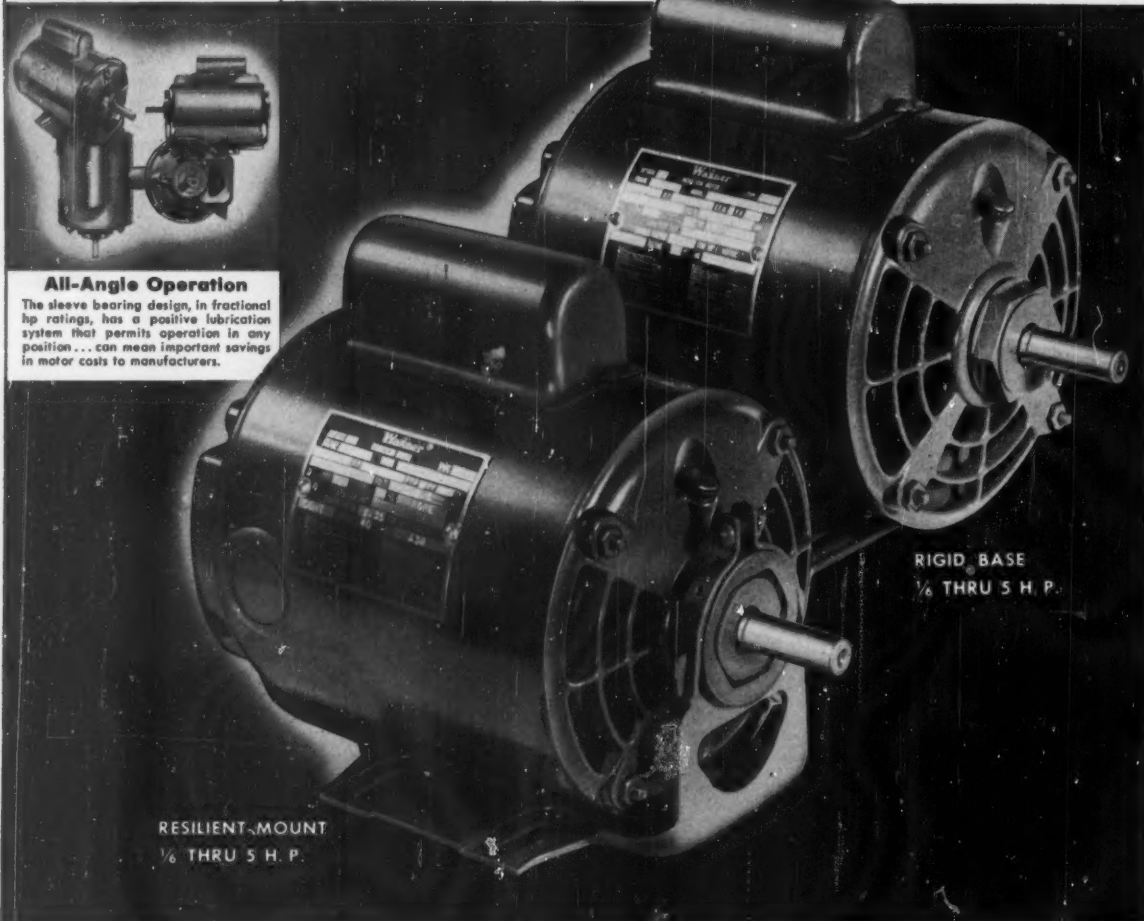
Wagner Type RK Motors pack more power into less space. Small enough to fit in tight spots, their ruggedness is built-in... permits direct mounting. They are available in a range from $\frac{1}{8}$ through 5 horsepower, with sleeve or ball bearings, and with rigid bases or resilient mountings. And, sleeve bearing fhp models can be operated in any position.

Get these motors from leading distributors in your city, or from Wagner Sales Offices in 32 cities across the country. Your Wagner Sales Engineer will be glad to help you select the right motor for your application. Wagner Bulletin MU-217 gives full details on Capacitor-Start Motors.

Wagner Electric Corporation

6404 Plymouth Avenue, St. Louis 33, Missouri

WH60-2





Morse engineers look to space from a down-to-earth viewpoint!

Sky is never the limit with the research and development staff working with the broad facilities at Morse.

Morse has grown up with the automotive industry. Its specialists have worked with designers and engineers in developing and perfecting the products of their imagination.

For more than 60 years, Morse has specialized in the science of kinematics. Perhaps its best known products are basic

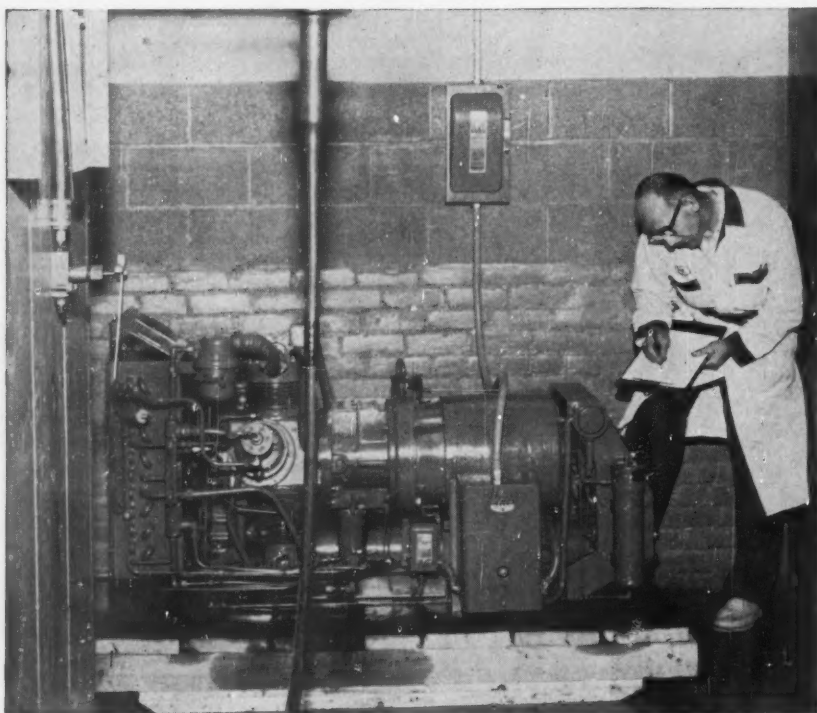
chain drives, gear reducers, couplings, and clutches in more major fields than you could count on the fingers of both hands.

Morse engineers, supported by Borg-Warner's ultra-modern research laboratory, can now offer a better way of giving your ideas a boost, and provide down-to-earth solutions to your problems in the race for space. Consult: Morse Chain Company, Dept. 6-10, a Borg-Warner Industry, Ithaca, N.Y. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ontario.

World's largest manufacturer of precision parts

MORSE **BW**

A BORG-WARNER INDUSTRY



This compact compressor supplies 15 CFM at 3500 psi in a high pressure hose testing facility. Similar machines are available for pressures up to 5000 psi, and volumes up to 80 CFM.

A COMPACT COMPRESSOR FOR HIGH PRESSURE AIR—UP TO 5000 PSI

Joy High Pressure Compressors are easily portable, highly reliable sources for high pressure air for testing. Originally developed for military jet aircraft and guided missile programs, Joy compressors in pressure ranges up to 5000 psi are field proven for reliability and durability. Currently, they are being used to test high pressure equipment, such as hose, valves, and fittings in numerous Research and Development installations.

These high pressure compressors are compact, multi-stage, V-type machines which are designed for continuous operation. They can be supplied for either electric or gasoline motor drive, and can be skid-mounted or equipped with wheels for complete portability.

If you have testing facilities which require extremely high pressure air, it will pay you to get complete details about the Joy machines. Write for Bulletin 1014-64B.



AIR MOVING EQUIPMENT FOR ALL INDUSTRY



Dust Collectors



Reciprocating & Dynamic Compressors



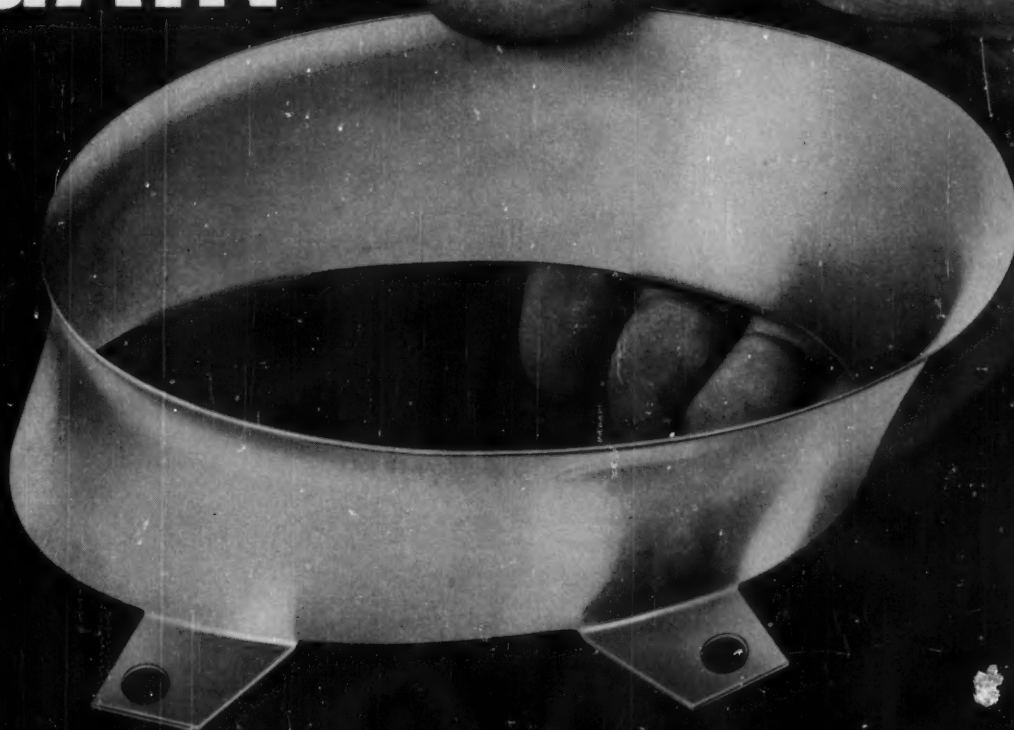
Fans and Blowers

JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company
(Canada) Limited, Galt, Ontario

AGAIN



Revere helps "fit the metal to the job"

**AND A MAKER OF FINE CARS
SAVES MONEY WHILE IMPROVING PRODUCT QUALITY**

Recently, a manufacturer of top-flight motor cars was having trouble in producing the above escutcheon for the front bumper lamps used on his newest model.

First of all, the breakage of the part was excessively high. Second, the escutcheon which is drawn at an angle, and contains a concave surface on the inside presented a problem in that, after buffing, polishing, and flash plating, the finish produced did not exactly match the chrome-plated bumper.

Revere's Technical Advisory Service suggested these difficulties might be overcome by using Revere 70-30 Brass Strip.

Here, again, by "fitting the metal to the job" Revere's Technical Advisory Service was able to reduce manufacturing costs while improving the quality of the product. Finish of parts was improved while finishing costs were reduced. Finished parts proved an excellent match. Switching to the more ductile metal resulted in less tool wear, while breakage was reduced to less than 1%. All this with little adjustment of existing press equipment.

Why not consult with Revere's Technical Advisory Service and take advantage of its extensive knowledge in "fitting the metal to the job." This Service has saved others money, why not you?



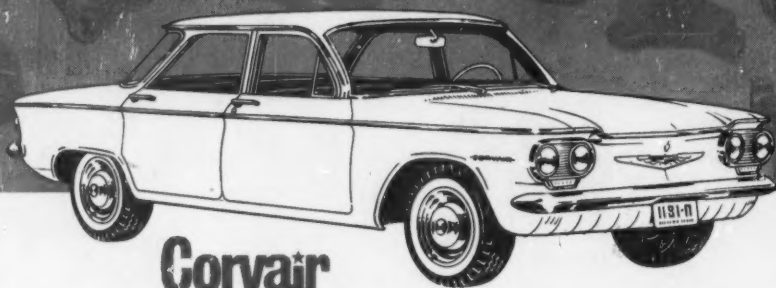
REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801
230 Park Avenue, New York 17, N. Y.

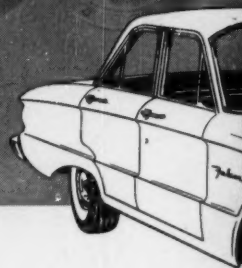
Mills: Rome, N.Y.; Baltimore, Md.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Brooklyn, N.Y.; Newport, Ark.; Ft. Calhoun, Neb. Sales Offices in Principal Cities. Distributors Everywhere.

Big Three's Little Three

to get Greater Strength
for Maximum



Corvair



Falcon

Each time a trio of these new cars rolls off the assembly lines at Ford, Chrysler Corporation and Chevrolet, another set of 67 Malleable parts goes into action to give American drivers more dependability, convenience and economy.

Valiant, Corvair and Falcon Use Greater Proportions of Malleable Iron Than the Three Conventional Cars!

Brand new from tread up, the Corvair, Falcon and Valiant are the result of intensive investigation, engineering and testing . . . all done to produce lighter,

more economical cars without sacrificing the safety and convenience demanded by the American public.

To accomplish this, the automobile industry's

These companies
are members of the



CONNECTICUT
Connecticut Malleable Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4
DELAWARE
Eastern Malleable Iron Co., Wilmington 99
ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Malleable and Steel Castings Co., Cicero 50

Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Link-Belt Company, Indianapolis 6
National Malleable and Steel Castings Co., Indianapolis 22

IOWA
Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

Rely On MALLEABLE

with Less Weight
Operating Economy....



Valiant

three newest creations use *more* Malleable in proportion to total materials than all other models of the same manufacturers. Why? Malleable provides *more strength per dollar* than any other metal, ferrous or non-ferrous. Malleable castings have *more strength per pound* than "light" metals. Being the *most machinable of all ferrous metals* of similar properties, Malleable speeds production . . . produces better parts. Malleable castings have proved uniquely dependable for critical applications in millions of cars now on the highways.

How many places are there in your operations where Malleable castings can improve your products and re-

duce your costs? Check now . . . send drawings or an outline of your requirements to any of the progressive Malleable castings producers who display this symbol—



Union Commerce Building, Cleveland 14, Ohio

MICHIGAN

Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA

Northern Malleable Iron Co., St. Paul 6

NEW HAMPSHIRE

Laconia Malleable Iron Co., Laconia

NEW YORK

Acme Steel & Malt. Iron Works, Buffalo 7

Frazer & Jones Company Division

Eastern Malleable Iron Co., Solway
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Malt. Iron Co., Westmoreland

OHIO

American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Malt. Iron Co., Ironton Div., Ironton
Dayton Malt. Iron Co., Ohio Malt. Div.,
Columbus 16
Maumee Malleable Castings Co., Toledo 5

National Malt. and Steel Castings Co.,

Cleveland 6

PENNSYLVANIA

Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS

Texas Foundries, Inc., Lufkin

WEST VIRGINIA

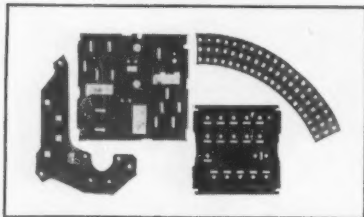
West Virginia Malt. Iron Co., Point Pleasant

WISCONSIN

Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works,
Milwaukee 46



LET SPAULDING GIVE YOU A HAND WITH YOUR TERMINAL BOARD PROBLEMS



Specially trained Sales Engineers . . . a broad choice of basic materials . . . extensive fabricating facilities . . . 85 years of experience. These Spaulding assets are at your disposal for terminal board material selection, design or production.

Spaulding's variety of basic materials provide unique combinations of properties to solve any problem in application. They have extremely high dielectric strength, low cold flow, good staking qualities, as well as toughness, chemical inertness, moisture resistance and dimensional stability. They are available fabricated to your exact specifications in completely uniform parts and in basic form such as sheets, rods and tubes.

Contact Spaulding. A Spaulding Sales Engineer can be at your office in a matter of hours with complete data on basic materials, fabricating service and engineering assistance.

SPAULDING FIBRE COMPANY, INC.

336 WHEELER STREET • TONAWANDA, NEW YORK

how to pick

the one right SOLID PIN for the job

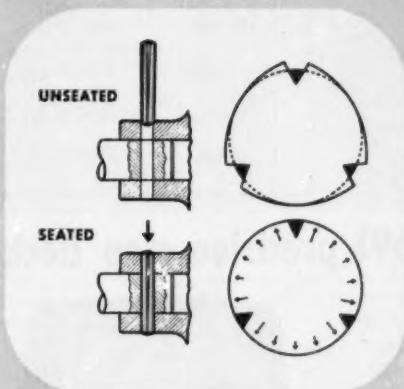
(the solid Groov-Pin is still the safest, surest way to pin two parts together)

The Groov-Pin has the holding power of a press fit pin *without* the need for close tolerances, and the ease of installation of a taper pin *without* the need for reaming.

You just drill the hole and drive the pin home. Once seated it stays there . . . no matter what the condition of shock or vibration.

Available in low carbon steel or other materials (stainless pins are Type 303, non-magnetic). Diameters from 1/32" to 1/2" are standard; larger sizes are special — but priced as standard in lots above 5000.

Write today for a copy of our comprehensive 28 page catalog. Groov-Pin Corporation, 1130 Hendricks Causeway, Ridgefield, N. J.



the unique GROOV-PIN locking principle

When a Groov-Pin is driven, the material displaced by the grooves is forced to flow back, setting up a powerful locking force. The ability of Groov-Pin to hold under severe shock and vibration . . . and its immunity to vibration fatigue . . . has been thoroughly proved by the billions in use!

GROOV-PIN

fastening gears, pulleys, sprockets, collars and cams to shafts.



type 1

The basic Groov-Pin and most widely used. Has three full length grooves tapering from maximum diameter at one end to nominal diameter at the other.

locating pins, stop pins, hinge pins.



type 2

Grooves cover only one half of pin length. Used where holding power is not critical. Speeds assembly because ungrooved portion acts as a pilot.

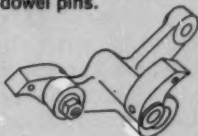
clutch and brake pedals to cross shaft; bike pedal arms to brake shafts.



type 3

Recommended for severe shock and vibration applications, its full length parallel grooves give it great holding power. Type 3H is essentially the same, but has pilots on both ends suiting it for hopper feeds.

stop pins, locating pins, dowel pins.



type 4

Similar to Type Two, but taper on grooves is reversed, meaning groove end is inserted first. This is particularly good on blind hole applications.

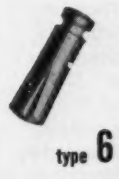
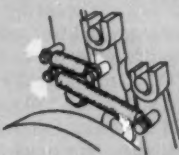
aircraft cowling, cover plates for buses, trucks.



type 5

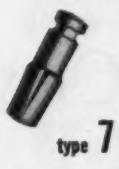
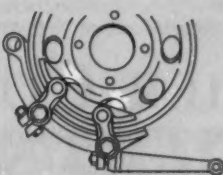
Has three oval grooves half the length of the pin, centrally located. Especially suited for quick removal and replacement. Type Five is also well suited for hinge pin applications.

spring anchors, spring control pins.



type 6

Same as Type Two, but with annular grooves on ungrooved end for spring anchor or retaining ring. Type Six is for through holes; Type Seven for blind holes.



type 7

In addition, annular grooves may be machined to your specification — for use with retainer rings, for example. See catalog for standards.

NEW running time meters register from 1/10 second to 99,999 hours

The new Cramer Type 632 running time meters, or time-totalizers, offer a simple, accurate means of recording elapsed time in many industrial or laboratory operations. They are applied to forecast the need for repair or servicing of equipment, to record total operating time or down time, and to supply time data for checking the operating performance of any circuit, machine, or electrically-powered system. Direct current and 400-cycle alternating current units, available in limited time ranges, fulfill the need for monitoring laboratory, military and experimental equipment where portability is often important.



TYPE 632

Also available with standard round dial

Operation

A Cramer constant-speed motor drives a precision drum-type counter when power is applied to the motor circuit. From the instant the motor circuit is closed, elapsed time is recorded on the counter, in the total ranges and unit counts shown in the table below. The high-torque and instant start-stop characteristics of the motor assure reliable accuracy at all counter speeds. Control circuits to the motor can be arranged to operate the counter during equipment running time, during idle time, or during any specified operational phase.

Features

TIME RANGES — 9,999.9 seconds to 99,999 hours (see Table).

MOTOR RATINGS — 115 or 220v ac, 60, 50, and 25 cycles. In limited time ranges, motors are available for 115v 400-cycle ac, or for specified voltages between 6 and 32v dc.

RESET — optionally available, in all time ranges.

DIALS — Chinese square (illustrated), or standard round.

MIL-SPEC UNITS — available in hermetically sealed construction, to meet applicable specifications of MIL-E-5272A.

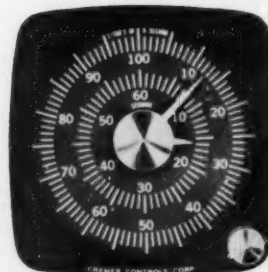
TYPE 632 TIME RANGES

COUNTS	TOTAL
1/10 sec.	9999.9 sec.
1 sec.	99999 sec.
1/100 min.	999.99 min.
1/10 min.	9999.9 min.
1 min.	99999 min.
1/10 hr.	9999.9 hr.
1 hr.	99999 hr.

and for 1/100-second accuracy, the Type 691 precision stop clock

In scientific research, and in many industrial and military applications requiring extremely precise time totalizing, Cramer Type 691 performs the same basic function as Type 632 but with still greater accuracy and flexibility. Total time ranges are either 60 minutes or 60 seconds. The inner scale on the dial reads directly in minutes or seconds. The outer scale reads either seconds or .01 minute for the 60-minute units, or .01 second for the 60-second unit. Reset is electrical, in 1/10

second, actuated either remotely or by a dial pushbutton. Motors, clutches and solenoids are available for all standard ac voltages and frequencies, and for 28 volts dc. One or two load switches (SPDT) are optionally available, for 5 amps at 115 and 230 volts ac or 2 amps at 28 volts dc. For load-switch operation, cams are precision cut to exact user specifications. Military units are available in hermetically sealed cases, to meet vibration, shock and other requirements of MIL-E-5272A.



TYPE 691

CRAMER CONTROLS

CORPORATION
Box 6, Centerbrook, Connecticut



Symbol of
Quality
to..



23,000,000
BOWLERS!

(and good healthful fun!)

The "baby split" has become as much a part of the language as the "banana split", and a "railroad" no longer merely describes a means of conveyance from one point to another.

To the 23,000,000 Americans who actively bowl—and to additional millions who watch the sport on television—they represent part of the terminology of the nation's fastest-growing sport.

And to millions of Americans the name "Brunswick" is synonymous with enjoyment of this indoor sport which draws no lines of sex, age or position in life.

As the nation's oldest and best-known bowling equipment firm, the Brunswick-Balke-Collender Company supplies millions of enthusiastic bowlers and thousands of spic-and-span bowling lanes with such necessary items as bowling balls, shoes, pins, scoring systems and other products.

But perhaps the most dramatic of the Brunswick products is its Automatic Pinsetter. A marvel of mechanization and of ingenuity in design, it must function steadily and accurately

game after game, night after night, week after week. There can be no breakdown or delay.

The Brunswick people have set up rigid standards for the material they use in their Automatic Pinsetter. This maintenance of quality and precision in all phases of manufacturing, this industry leadership, have made the name Brunswick a symbol of dependability.

DURKEE-ATWOOD V-Belts are an integral part of the Brunswick Automatic Pinsetters, which have been such a boon to bowling. They were selected because of their proven ability to give long and consistent service under the most difficult and demanding conditions. If you have a V-Belt problem that requires special attention and service, call your Durkee-Atwood distributor or write Durkee-Atwood Company, Minneapolis 13, Minnesota.



Look for the  on your V-Belts

DURKEE-ATWOOD V-BELTS

DURKEE-ATWOOD COMPANY • MINNEAPOLIS 13, MINNESOTA

Circle 451 on Page 19



BISHOP

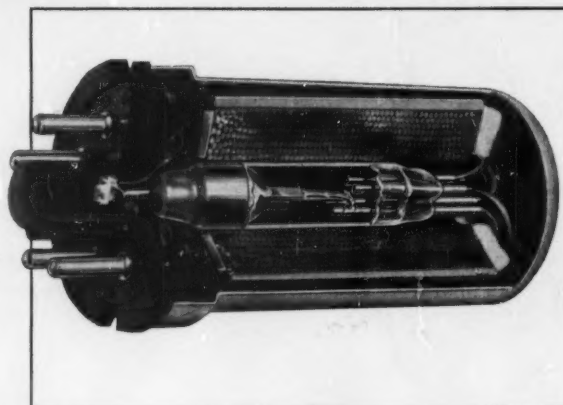
Tubular Products NEWS

"METALS FOR PRECISION AND PERFORMANCE"

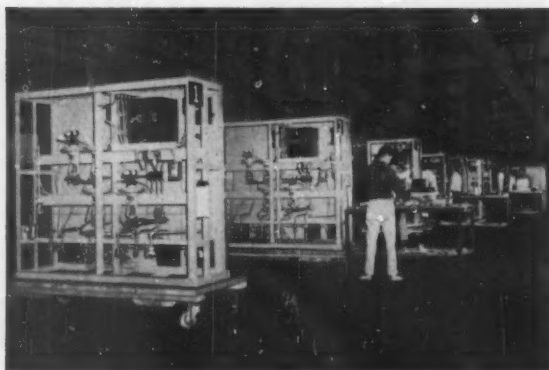
C. P. CLARE'S MERCURY-WETTED CONTACT RELAYS PERFECTLY SEALED WITH GLASS-TO-METAL SEALING ALLOY

C. P. Clare & Company, Chicago, Illinois, produces a complete line of mercury-wetted contact relays characterized by long life, high speed of operation and no contact bounce. To supply relays that have a conservative life expectancy of more than a *billion* operations requires absolute perfection in all phases of manufacturing. C. P. Clare uses BISHOP's #52 alloy tubing for the critical tubular stems of these relays. Mercury and hydrogen at 150 psig are introduced through this connecting stem—which is then sealed off by welding and forging. Can glass-to-metal sealing alloys solve any of your problems? BISHOP makes a complete line . . . use the coupon for details.

Circle 452 on Page 19



TUBING TAKES 5,400 PSI IN HONEYWELL'S MISSILE CHARGING SYSTEM



Super pressure stainless steel tubing connects many components of the cubicles illustrated. Minneapolis-Honeywell's Missile Equipment Division, Pottstown, Penna. builds these control cubicles that make up the gas charging system for the Bomarc missile. BISHOP supplies Honeywell with two sizes of 304 seamless super pressure tubing for this application. During charging of the missile, tubing handles pressures up to 5,400 psi. If you use small diameter tubing—super pressure, commercial quality or other—consider BISHOP. Use the coupon for a copy of BISHOP's Tubular Products Bulletin.

Circle 453 on Page 19



J. BISHOP & CO.

platinum works

FOR HELPFUL DATA USE THIS HANDY COUPON

- ☐ Glass-To-Metal Sealing Alloy Data
- ☐ Tubular Products Bulletin No. 12
- ☐ Special Tubing Data
- ☐ Platinum Products Catalog No. 4

Check information you'd like and mail to
J. BISHOP & CO.,
45 King St., Malvern, Penna.

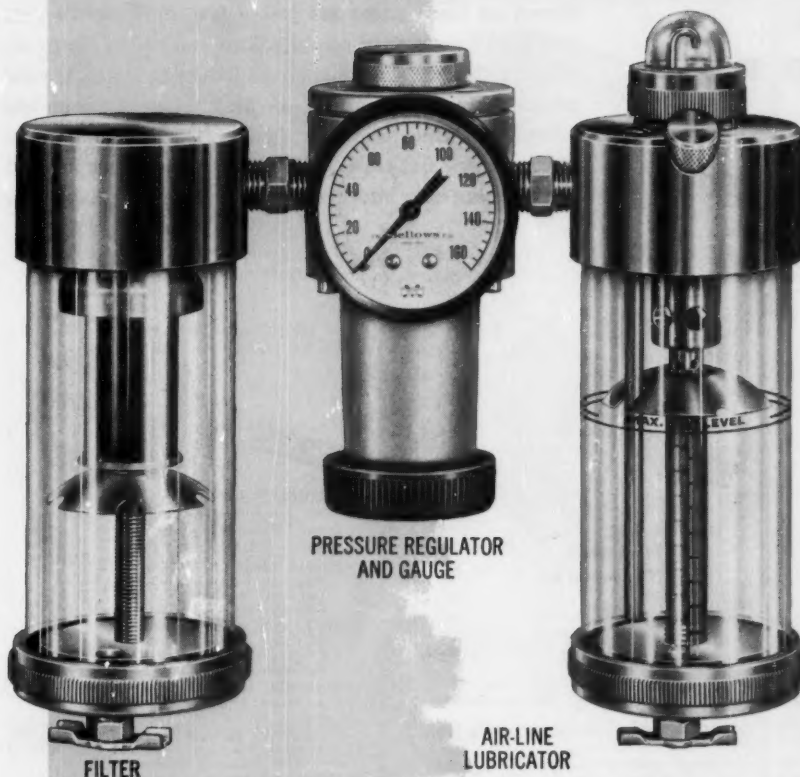
Name _____
Position _____
Company _____
Address _____
City _____ Zone _____ State _____

Tubular Products Division

45 KING STREET, MALVERN, PENNA.
NIagara 4-3100

THIS IS THE BISHOP LINE:
Products of all the Platinum Metals...
Small diameter Stainless Steel,
nickel and special alloy tubing

AIR-POWERED EQUIPMENT



**PERFORMS MORE
EFFICIENTLY**

**COSTS LESS
TO MAINTAIN**

**GIVES LONGER
SERVICE LIFE**

with a

Bellows LUBRI-AIR[®] CONTROL UNIT

Free Bulletin LA-15
gives complete informa-
tion. Write for your copy
today. Address Dept. MD
160. The Bellows Co.,
Akron 9, Ohio.

HERE'S WHY: Once adjusted to the requirements of a particular air system, the Bellows Lubri-Air Control Unit automatically filters harmful dirt and moisture out of the air stream (40 micron filter element standard; 5, 10 and 20 micron units available) . . . automatically regulates air pressure by compensating for fluctuations in air supply and variation in cfm requirements of pneumatic equipment . . . automatically lubricates air-operated equipment by providing the correct amount of misted oil to the air stream. Bellows Lubri-Air Control Units are available in 1/4", 3/8", 1/2", 3/4" and 1" sizes.

OTHER INDUSTRIAL DIVISIONS OF
IBEC: Sinclair-Collins Valve Co.,
Valvair, Akron, O.; V. D. Anderson
Co., Cleveland, Ohio.

675-C

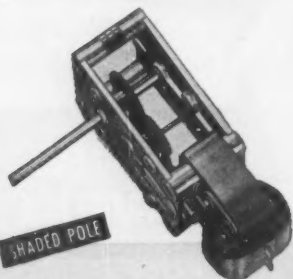
The Bellows Co.
DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)
AKRON 9, OHIO

New from HOWARD...a Complete

- **UNIVERSAL**
- **SHADED POLE**
- **INDUCTION**

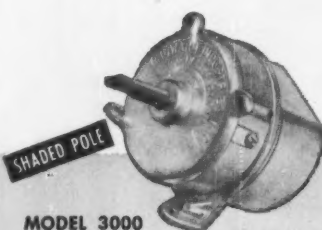
Ratios from 3:1 to 2700:1

Shown on these pages are just a few of Howard's gear motors. Thousands of combinations and ratios are available in universal, shaded pole and induction types. If your product requires gear motors, check today for complete information. Give us details of your application and quantities required and we will be happy to submit samples and quotations or more information on standard types available.



MODEL 300

TYPE: Two Pole Shaded Pole AC—3200 R.P.M.
 WIDTH: 2-15/32". LENGTH: 3-7/8".
 MAXIMUM CONTINUOUS TORQUE OZ.
 IN. (at 11/16" Stacking Length).
 *1 R.P.M. 500 oz. in.
 *150 R.P.M. 3.3 oz. in.
 MAXIMUM INTERMITTENT TORQUE OZ.
 IN. (at 11/16" Stacking Length).
 *1 R.P.M. 750 oz. in.
 *150 R.P.M. 5 oz. in.
 VOLTS: 12 to 115.
 BEARINGS: Porous bronze sleeve bearing with oil reservoir.
 *Torques at intermittent speeds are inversely proportional to speed.



MODEL 3000 with GEAR UNIT

TYPE: 2 Pole Shaded Pole.
 DIAMETER: 3-7/16".
 LENGTH: 3-5/8" to 4-1/2".
 MAXIMUM CONTINUOUS TORQUE* 1
 R.P.M. (at 1-1/2" Stacking Length):
 45 in. lbs.
 MAXIMUM INTERMITTENT TORQUE* 1
 R.P.M. (at 1-1/2" Stacking Length):
 70 in. lbs.
 BEARINGS: Porous bronze sleeve type with oil reservoir.
 *With external fan. Torques at other speeds from 1 to 400 rpm available upon request.



MODEL 2400

TYPE: 4 Pole Induction.
 DIAMETER: 2-9/16" square.
 LENGTH: 2-3/8" to 3".
 SINGLE PHASE CAPACITOR MOTOR:
 Maximum Torque oz. in.—1.
 Full Load Speed R.P.M.—1150.
 Bearings—RBC—Ball. RWC—Sleeve.
 TWO PHASE MOTOR:
 Maximum Torque oz. in.—1.5.
 R.P.M.—1150.
 Bearings: RBT—Ball. RWT—Sleeve.
 BEARINGS: Porous bronze sleeve type with oil reservoir, or grease sealed ball bearings.
 GEAR UNITS: Ratios 6:1 to 3600:1. Spur gears throughout. The high speed pinion is cut on the shaft, assuring accuracy and concentricity, and maximum strength is achieved by supporting the output shaft in large porous bronze bearings.



MODEL 2500

TYPE: 2 or 4 Pole Induction.
 DIAMETER: 2-9/16" square.
 LENGTH: 1-7/8" to 2-3/8".
 SPEED: *1200 to 3600 R.P.M.
 H.P.: 1/300 to 1/1400.
 MAXIMUM TORQUE oz. in. *1.6 to 3.5.
 BEARINGS: *Ball or sleeve.
 *Dependent on type of motor used; i.e. Non-Synchronous Capacitor Motors, Torque Motors, Standard Synchronous Motors, Hysteresis Synchronous Motors.
 GEAR HEAD: Ratios from 6:1 to 3600:1. Torques up to 300 in. oz. at low speeds. Range of output speeds from 1/2 r.p.m. to 600 r.p.m.
 Spur gears are used throughout. The high speed pinion, cut on the rotor shaft, assures extreme accuracy, and maximum strength is achieved by supporting the output shaft in large, solid bronze bearings.



MODEL 2900 with GEAR UNIT

TYPE: 2 Pole, 4 Pole Induction.
 DIAMETER: 3-5/16".
 LENGTH: 7-5/64" to 8-11/64".
 SPEED: 1650 to 3600 R.P.M. depending on type of motor used—Non-Synchronous, Standard Synchronous, Hysteresis Synchronous, or Torque.
 H.P.: 1/70 to 1/15 depending on length of stacking.
 TORQUE OUTPUT: Up to 60 in. lbs. depending on ratio.
 BEARINGS: Permanently lubricated and sealed ball bearings.
 RATIOS: 10:1 to 60:1.

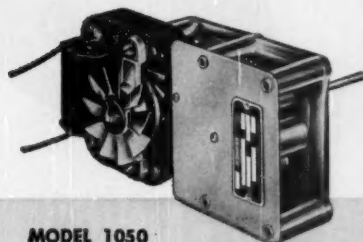


MODEL 29-500 with GEAR UNIT

TYPE: Universal AC/DC or Shunt.
 DIAMETER: 3-5/16".
 LENGTH: 7-13/64" to 7-37/64".
 SPEED: 5000 to 10,000 R.P.M.
 H.P.: 1/70 to 1/4 depending on length of stacking.
 TORQUE OUTPUT: Up to 60 in. lbs. depending on ratio.
 BEARINGS: Permanently lubricated and sealed ball bearings.
 RATIOS: 10:1 to 60:1.

line of Fractional H.P. Gear Motors

2 POLE, DOUBLE BEARING



MODEL 1050

OUTPUT SPEEDS—1 rpm and up.

GEARS—Molded nylon in high-speed for quiet operation, stamped, cut or sintered in low-speed section.

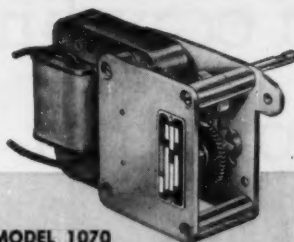
BEARINGS—Sintered porous bronze with large oil reservoirs for assured self lubrication.

MOUNTING—Front only; choice of ten holes tapped as required.

ROTATION—Unidirectional (CW or CCW).

SHAFT—3/16 in. dia. std. with length to meet requirements.

starting torque, in. lbs.	no load rpm	full load				stack A, in.
		torque, in. lbs.	rpm	input (115-V) amps. watts	gear ratio	
20	6.8	33	6	.34 18	500:1	%
15	10.2	24	9	.34 18	333:1	%
7	17	19	15	.46 24	200:1	%
5	43	11	30	.46 24	100:1	%
2.25	75	4.5	68	.46 24	45.4:1	%
2.0	122	2.4	108	.75 35	27.8:1	%
1.5	159	1.9	140	.81 40	21.4:1	%



MODEL 1070

OUTPUT SPEEDS—30 rpm and up.

GEARS—Molded nylon in high-speed section for quiet operation; stamped, cut or sintered in low-speed section. Also available, when specified, with cut gears throughout.

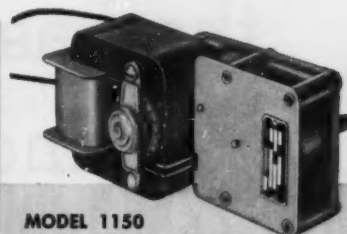
BEARINGS—Sintered porous bronze with large oil reservoirs for assured self-lubrication.

MOUNTING—Front only; choice of three holes tapped #8-32 and/or two .161 in. dia. holes.

ROTATION—Unidirectional (CW or CCW) as specified.

SHAFT—3/16 in. dia. std. with length to meet requirements.

starting torque, in. lbs.	no load rpm	full load				stack A, in.
		torque, in. lbs.	rpm	input (115-V) amps. watts	gear ratio	
2.25	82	4.5	74	.46 24	37.8	%



MODEL 1150

OUTPUT SPEEDS—60 rpm—other gear trains for different output speeds available, state requirements.

GEARS—Molded nylon in high speed section for quiet operation. Stamped, cut or sintered for low-speed section.

BEARINGS—Sintered porous bronze with large oil reservoir for assured self-lubrication.

MOUNTING—Front only, choice of ten holes tapped as required.

ROTATION—Unidirectional (CW or CCW as specified).

SHAFT—1/4 in. dia. std. with length to meet requirements.

starting torque, in. lbs.	no load rpm	full load *				stack A, in.
		torque, in. lbs.	rpm	input (115-V) amps. watts	gear ratio	
16	75	24.5	60	3.1 124	50:1	1 1/4

*Intermittent duty (10 seconds On, 30 second OFF continuously).

GEAR REDUCTION UNITS

Designed for direct mounting on Howard motors, the speed reducers illustrated in this section give a wide range of speeds and torque in both open and closed types; single or two stage. Closed units are grease packed for efficient lubrication with minimum maintenance. For heavy duty, high torque applications, Models A-7 and A-12 are especially recommended. Twelve Howard universal motors (not shown)

are available as gear motors with the gear units illustrated. Hundreds of standard ratios permit accurate selection of output speed. Most of the gear units can be supplied with double shaft extensions where required. Our gear reducers are intended for use only with Howard motors. Ratings are maximum under ideal operating conditions. Each application requires careful consideration based on having description of Load & Duty Cycle.



MODEL A-1
Single Reduction, Open
Maximum Ratio: 58:1
Minimum Ratio: 3:1
TORQUE
Continuous Duty: 5 in. lbs.
Intermittent Duty: 10 in. lbs.
Efficiency: Max. 45%



MODEL A-3
Double Reduction, Open, With Mounting Pad
Maximum Ratio: 2700:1
Minimum Ratio: 40:1
TORQUE
Continuous Duty: 5 in. lbs.
Intermittent Duty: 10 in. lbs.
Efficiency: Max. 30%



MODEL A-4
Single Reduction, Closed
Maximum Ratio: 58:1
Minimum Ratio: 3:1
TORQUE
Continuous Duty: 5 in. lbs.
Intermittent Duty: 10 in. lbs.
Efficiency: Max. 45%



MODEL A-5
Double Reduction, Closed
Maximum Ratio: 2700:1
Minimum Ratio: 40:1
TORQUE
Continuous Duty: 10 in. lbs.
Intermittent Duty: 20 in. lbs.
Efficiency: Max. 30%



MODEL A-6
Single Reduction, Closed
Maximum Ratio: 60:1
Minimum Ratio: 3:1
TORQUE
Continuous Duty: 12 in. lbs.
Intermittent: 25 in. lbs.
Efficiency: Max. 65%



MODEL A-7
Double Reduction Closed, Heavy Duty
Maximum Ratio: 2600:1
Minimum Ratio: 21.5:1
TORQUE
Continuous Duty: 50 in. lbs.
Intermittent Duty: 100 in. lbs.
Efficiency: Max. 50%



MODEL A-12
Combined Worm and Spur Gears
Maximum Ratio: 525:1
Minimum Ratio: 6.7:1
TORQUE
Continuous Duty: 100 in. lbs.
Intermittent Duty: 250 in. lbs.
Efficiency: Max. 50%



MODEL A-26
Single Reduction, Closed
Heavy Duty
Maximum Ratio: 60:1
Minimum Ratio: 3:1
TORQUE
Continuous Duty: 50 in. lbs.
Intermittent Duty: 100 in. lbs.
Efficiency: Max. 80%

POWERED BY

HOWARD

HOWARD INDUSTRIES, INC., 1735 State St., Racine, Wis., Telephone ME 2-2731, Teletype: RAC344

Sales Offices:

Camden, New Jersey, 300 Broadway, WO 4-9733
Chicago 4, Ill., 208 S. LaSalle St., CE 6-5126
Cincinnati 2, O., 1077 Celestial St., PA 1-2985

Festus, Mo., 1049 Front Street, YE 7-3606
Los Angeles 36, 942 S. Le Brea Ave., WE 8-2444
New York 1, Empire State Bldg., LO 4-7992
Tyler, Texas, 2512 Sheryl Lane, TY 4-5335

Representatives in Principal Cities—Consult Your Classified Phone Book

DIVISIONS: **EMC** ELECTRIC MOTOR CORPORATION

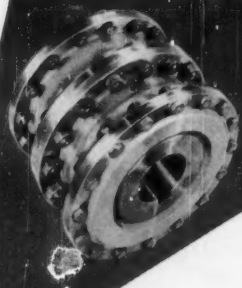
CC CYCLOHM MOTOR CORPORATION

REP RACINE ELECTRIC PRODUCTS

LS LOYD SCRUGGS COMPANY



the basic coupling
principle that
couldn't be
improved...

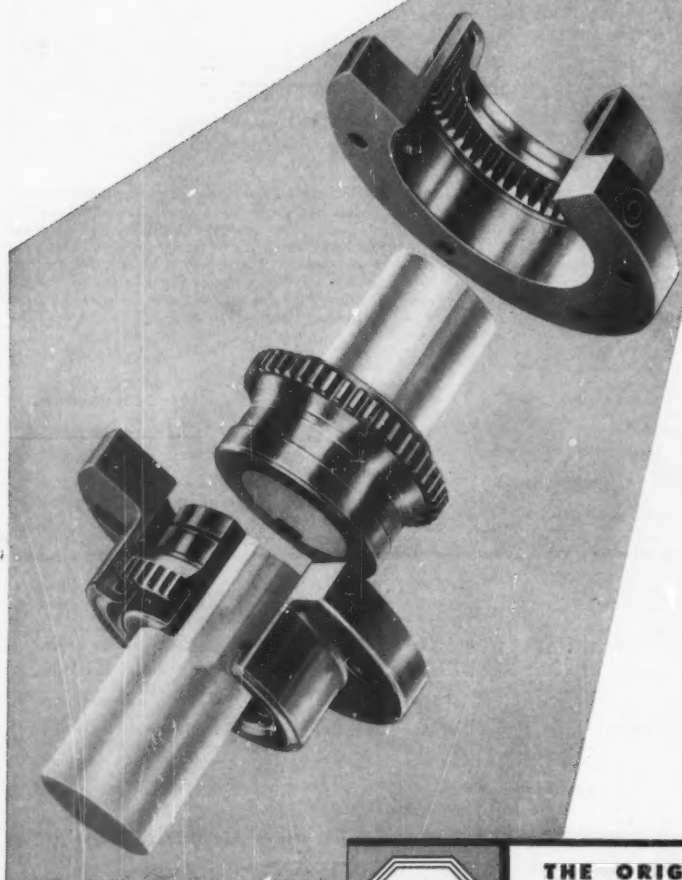


**This principle
makes every
Fast's coupling
...large or small
...out-perform
all others**

The principle embodied in Koppers gear-type, self-aligning Fast's couplings couldn't be improved by anyone. Throughout industry, Fast's couplings are accepted as the most dependable couplings on the market. Experience has proved that they frequently *outlast the equipment* they connect.

Fast's couplings are sufficiently comprehensive in types, sizes and versatility to meet almost every known need for couplings. Available in forged steel for shaft sizes from $\frac{3}{4}$ " to $6\frac{3}{8}$ " and in cast steel for shaft sizes from $5\frac{1}{2}$ " to 32".

Nearly 40 years of coupling experience guarantees that Koppers can supply the right coupling engineered for a given application. For the booklet describing Fast's couplings applicable to your equipment, write today to: KOPPERS COMPANY, INC., Fast's Coupling Department, 5601 Scott Street, Baltimore 3, Maryland.



THE ORIGINAL

FAST'S Couplings

Engineered Products Sold with Service



*Furniture
Manufacturers
Call it*

"BRIDGEPORT FREE-ER MACHINING BRASS ROD"



Manufacturers of a wide variety of products find Bridgeport Free Machining Brass Rod eminently suited to their items—from both a production and beauty point of view. Furniture manufacturers are but one successful example.

The production steps involved in manufacturing such furniture are frequently numerous and complex. For example, a solid brass tea cart such as shown here may represent some ten or more separate production steps. These include cutting, bending, drilling, tapping, twisting, polishing and lacquering, most of which are done on high-speed automatic equipment. The objective here, as with any screw machine operation, is high *uninter-*

rupted speeds. An increasing number of manufacturers are achieving these uninterrupted speeds with Bridgeport rod and tubing of various shapes and sizes. They find, on a comparative basis, that the high quality of Bridgeport Free Machining Brass is *constant* and can be depended on from end to end.

Bridgeport Free Machining Brass is but one of the many "easy-does-it" metals that are standard stock and immediately available from nearby Bridgeport Warehouses. An inquiry to your local Bridgeport Sales Office may lead to improving your product, increasing your production rate and raising your profits. Call today!



BRIDGEPORT BRASS COMPANY

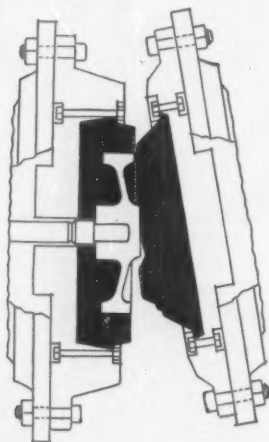
Bridgeport 2, Connecticut • Sales Offices in Principal Cities
Specialists in Metals from Aluminum to Zirconium

Unique Mill Forges and Rolls circular products in one operation

In less than one minute, this Bethlehem mill—the only one of its kind in the country—turns out a top-quality impression-die steel forging at a cost that's hard to match.



This is Bethlehem's famed circular-products mill—the Slick Mill. Named for its designer, Edwin E. Slick, this unique machine produces impression-die circular forgings ranging from 10 in. to 46 in. OD; as-rolled weights ranging from 100 to 2,000 lb. It handles almost any grade of steel—carbon, alloy or stainless, as well as certain heat-resistant grades.



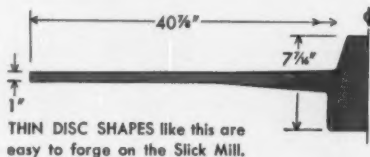
How It Works

Designed to operate in a horizontal plane, Bethlehem's Slick Mill is constructed with two *revolvable* spindles on

which face plates are mounted. These face plates support the impression dies that form the steel billet into shape by a combination press and rolling action.

After the steel billet is heated and descaled, it is centered between the dies of the Slick Mill. Then a 1500-ton hydraulic ram actuates the spindle on the straight side of the mill, upset forging the billet. When this cycle is completed, a 2,000-hp motor actuates the spindle on the angle side of the mill and the rolling cycle begins. By continuing the upsetting action and rotation of the dies and work, the material flows into the recesses of the dies, resulting in the desired shape. *The entire rolling cycle takes about one minute.*

After rolling, excess material in the form of flash is sheared off; the hub, when necessary, is punched; and the forging is inspected.



Cost-Saving Features

Quick operation: Only one minute is needed to convert a heated slug into a contoured forging, whether the product weighs 100 or 2,000 lb.

Quick die changes: Only 15 minutes are needed to change and set up dies. Even production runs as small as 25 or 50 pieces are economical.

Low die charges: Since contact time between die and work is very brief, and because there is no impacting, low-cost die blocks can be used. In many cases, die charges are $\frac{1}{3}$ to $\frac{1}{2}$ less than conventional impression dies.

Less steel needed: Utilizing the principle of forging design, the Slick Mill can produce lighter-weight sections without sacrificing strength.

Good physical characteristics: The process insures excellent grain flow, machinability and soundness.



Bethlehem's Slick Mill is readily adapted to jobbing or production quantities of forged circular products such as: gear blanks, fly wheels; crane track wheels; sheave wheels; brake drums; clutch discs; couplings; tire moulds; and turbine or compressor wheels. Products may be specified as-rolled or rough machined to specifications.

Your inquiry—whatever the quantity involved—will receive prompt attention. Call or write the Bethlehem sales office nearest you today.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

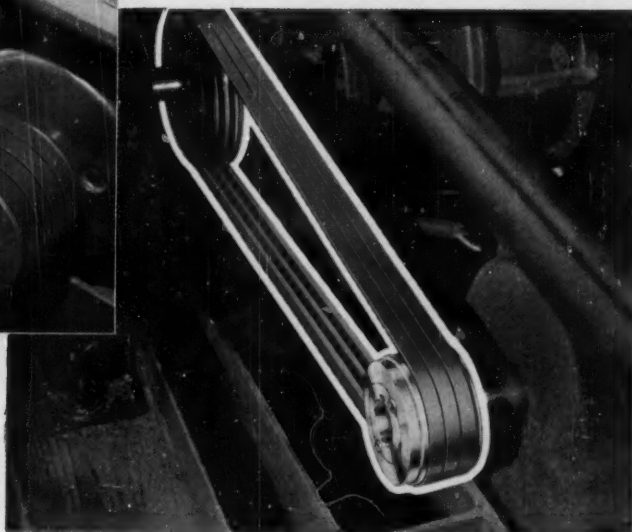
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL





Before: Four standard belts were required to drive the clothes pressing unit manufactured by a Utah company.



After: Three Gates Super HC V-Belts now handle the redesigned pressing unit drive — save more than 16 pounds in drive weight — 24% in drive cost.

Utah manufacturer cuts drive cost 24% with new high capacity V-Belt

Drive weight reduced 16 pounds per unit!

This manufacturer is just one of many who have already turned to Gates Super HC V-Belts to achieve far more compact, lighter weight, lower cost V-belt drives for all types of machines. With new Super HC

V-Belts, sheave dimensions can be reduced 30% to 50%, overall space up to 50%, and drive weight by 20% and more.

A product of Specialized Research in the world's largest V-belt laboratories at Gates, the Super HC V-Belt Drive is already standard equipment on production models in virtually every industry.

Engineering Service Nation-Wide

Whatever your plant's power transmission design problem, wherever you are, your nearby Gates Distributor or Field Representative is ready

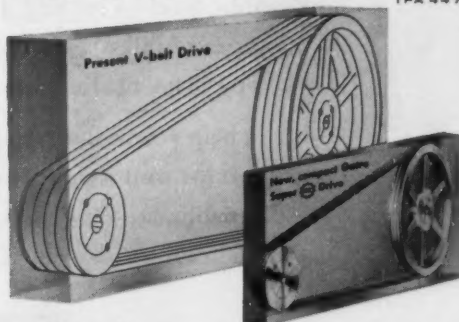
to assist you to cut space, weight, and costs with Super HC. Ask him for a copy of "The Modern Way to Design Multiple V-Belt Drives."

TPA 447

The Gates Rubber Company, Denver, Colorado
Gates Rubber of Canada Ltd., Brantford, Ontario



World's Largest Maker of V-Belts



Gates Super HC V-Belt Drives

same hp capacity
in smaller "package"

Republic High-Performance Titanium for the X-15

In a number of highly stressed components subject to extreme high and low temperature fluctuations, *high-performance* titanium in the X-15 Research Vehicle will help take man higher and faster than he has ever been before.

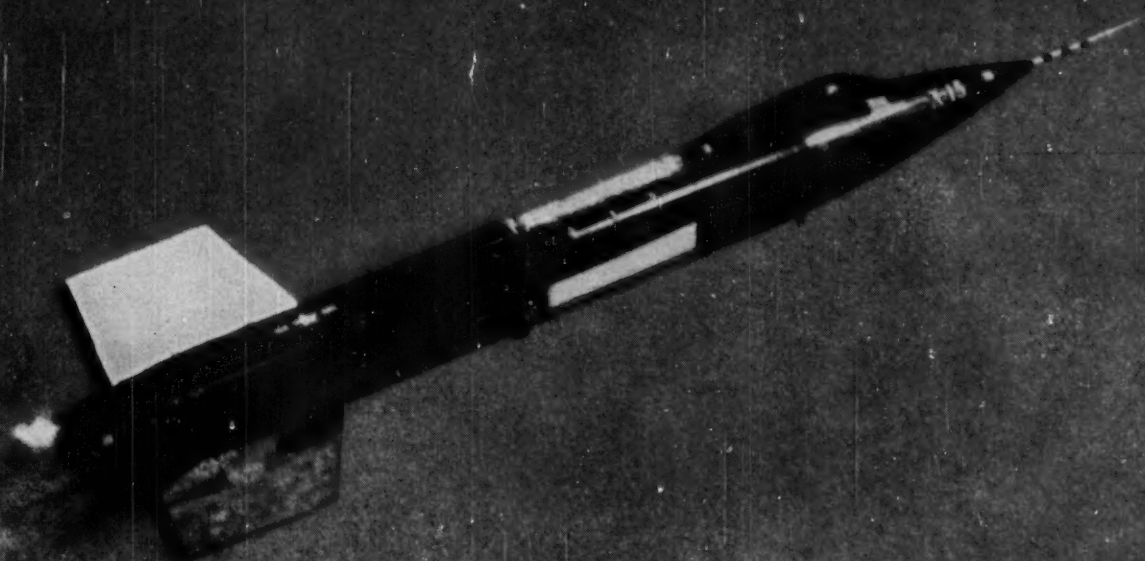
Republic Steel—a leading supplier of titanium, and the nation's largest producer of stainless and alloy steels—is supplying North American Aviation with Type 110A titanium for internal structures on the X-15 project.

Let us help you utilize *high-performance* metals to increase strength, resist heat, or trim weight. Write Republic Steel, Dept. MD-8591, 1441 Republic Building, Cleveland 1, Ohio.

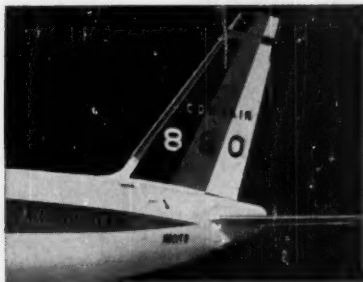
Please indicate if you would like a titanium metallurgist to call.

Circle 460 on Page 19

REPUBLIC STEEL *Where Steels are*



FIRST POWERED FLIGHT of the North American X-15 came on September 21, 1959, over Edwards AFB. Carrying a full load of fuel (note frost from liquid oxygen at top and bottom of fuselage), the X-15 flew under power for 3.5 minutes at speeds in excess of Mach 2.



REPUBLIC STAINLESS STEEL is used in leading edges of the Convair 880's vertical fin and horizontal stabilizer where anti-icing is accomplished through electrical heating of the metal. Use of Republic ENDURO® Stainless Steel increases strength and heat-resistance, permits thinner, lighter gages. Types 301 and 302 are readily formed into desired shapes by cold forming, drawing, and bending operations.

Circle 461 on Page 19

REPUBLIC'S NEW HIGH STRENGTH POWDER, TYPE HS6460

is ideal for sinterings of highly stressed components. Provides minimum tensile strength of 60,000 psi at 6.4 density as sintered . . . 100,000 psi after heat treatment. Maximum of .004% shrinkage from die size at 6.4 density. Available in quantities up to and including 12 tons or multiples. Can be used with existing operating equipment.

Circle 462 on Page 19

REPUBLIC VACUUM-MELTED ALLOYS heat treated to tensile strength levels of 270,000 to 300,000 psi are produced in fifteen thousand-pound heats for missiles such as the Minuteman. Vacuum arc process minimizes segregation and center porosity. Nonmetallic inclusions are reduced in number and size. Transverse ductility at high strength levels is also greatly improved.

Circle 463 on Page 19



Made to Meet the Challenge of Acceleration



IRREGULAR SHAPES IN GEARS AND OTHER PARTS

**... no problem with
Fellows Gear Shapers**

Irregular shapes can be production machined accurately and quickly on the Fellows Gear Shaper. The Fellows principle of gear generating with a reciprocating cutter makes it a simple job to generate square or elliptical shapes, cams, pawls, pump rotors, and many other contours, both internal and external.

With the proper cutter and, depending on the part design, a fixture in which the work is located off-center or one which varies the center distance relationship of cutter and work as the cutting progresses, quantity production of parts such as those shown here is as fast and simple as cutting spur gears.

Using special cutters and fixtures designed by Fellows, the Gear Shaper can produce a remarkably wide variety of contours at high production rates. For example, one section of the cutter shown below finish cuts one side of this very odd shaped pawl. Cutting is almost continuous with a magazine type fixture having eight loading stations. For further information on generating irregular shapes on the Fellows Gear Shaper get in touch with any Fellows office.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont, U.S.A.
Branch Offices:

- * 1048 North Woodward Ave., Royal Oak, Mich.
- * 150 West Pleasant Ave., Maywood, N.J.
- * 5835 West North Avenue, Chicago 39
- * 6214 West Manchester Ave., Los Angeles 45



**THE
PRECISION
LINE**

Fellows

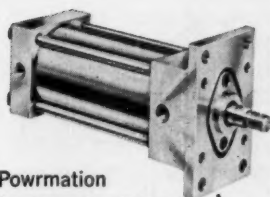
Gear Production Equipment

...unusual features solve your cylinder problems

NEW HANNA *Powrmation* SERIES 1000 CYLINDERS

Pressure Safe Tube Seals

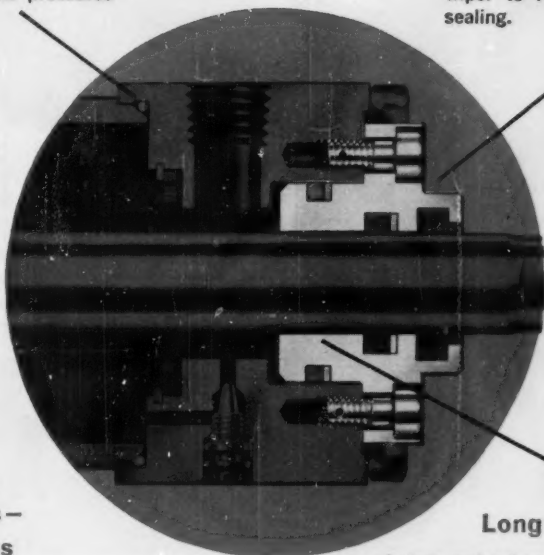
on the outside diameter of the tube create the most positive seal possible at all pressures from zero to maximum.



Powrmation
Rectangular Flange
Rod End

One Piece Steel Heads— Welded Steel Mountings

for maximum strength, perfect alignment... superior to bolted assembly. Mountings carry maximum cylinder load with ample safety margin.



Fast Change Cartridge Gland

has leak-proof, low-friction rod seal and a rod wiper to remove dirt and to provide extra sealing.



Powrmation
Side Lug
Mounting

Long Lubricated Bearing

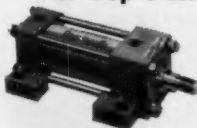
of close-grained nodular iron with high graphitic content... one of the finest bearing materials. Rod seal on external side of bearing provides automatic bearing lubrication by hydraulic fluid or airborne lubricant.

POWRMATION CYLINDERS FOR AIR TO 250 PSI • HYDRAULIC TO 1000 PSI • BORES: 1½" THROUGH 14"

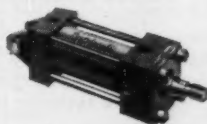
All good cylinders have "features" but few have a combination of really *Unusual* features that assure superior cylinder performance and dependability... New Hanna Powrmation Cylinders have. The features shown above and several others like: Unique, Check-Valve Cushions; Low Friction Nodular Iron Pistons; Posi-

tive Seal Block Vee Packings; Chrome Plated High Strength Steel Rod;—all these together with Hanna precision manufacturing and Hanna Field Engineering Service are the reasons why it will pay you to specify Powrmation Cylinders... they meet J.I.C. recommendations and have dimensional interchangeability.

For Top Performance in Hydraulic Pressures



2000 PSI/3000 PSI Non Shock
HANNA POWRDRAULIC
Series 2000 CYLINDERS
Bores 1½" thru 8"



Write for Catalog 1000

or ask Your Hanna
Representative—
see the Yellow Pages
or Sweet's Design
Catalog for his name

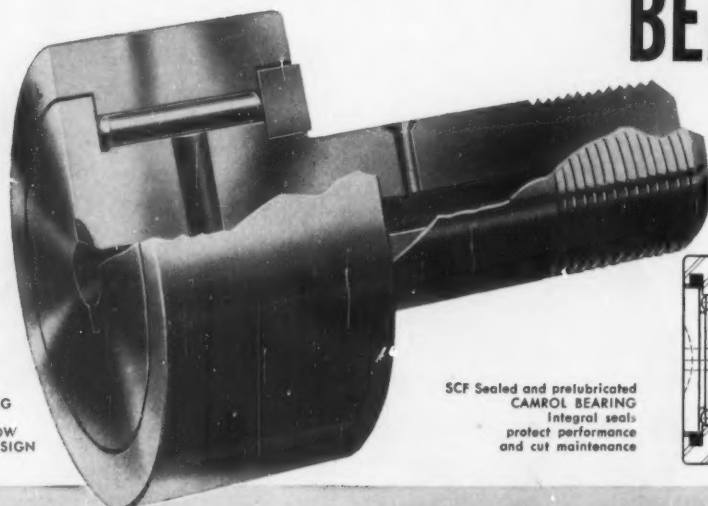


HANNA ENGINEERING WORKS

HYDRAULIC AND PNEUMATIC EQUIPMENT... CYLINDERS... VALVES

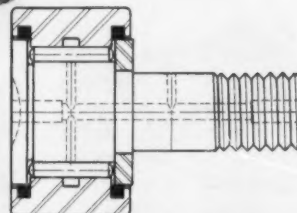
1751 Elston Avenue • Chicago 22, Illinois

MCGILL® **CAMROL®** BEARINGS



CF CAMROL BEARING
CUT AWAY TO SHOW
INTEGRAL STUD DESIGN

SCF Sealed and prelubricated
CAMROL BEARING
Integral seals
protect performance
and cut maintenance



SIMPLIFY DESIGN and ASSEMBLY

**Stock sizes eliminate the
cost of procuring and assembling
improvised unit components**

You can simplify design and cut cost with CAMROL precision anti-friction cam followers—built for the job. Complete units, with established performance ratings are available from stock in standard roller diameters from 1/2" to 4". Capacities to 20,480 lbs. at 100 R.P.M.

**Precision anti-friction
bearing accuracy**

Precision construction, including concentricity of stud to outer race OD, provides accurate alignment of machine members.

High load capacity in limited space

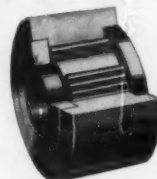
A full complement of race width rollers provides maximum capacity and ability to withstand heavy intermittent shock loading. The extra heavy outer ring and specially heat treated stud add durability and insures dependability of machine operation. Bolt mounted ball bearings crack under equivalent loads and plain bearings require constant oil lubrication.

**Integral seals retain lubrication
—keep dirt out**

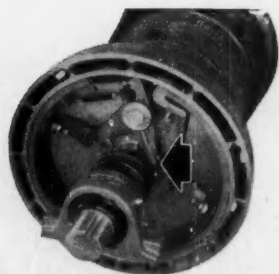
SCF Sealed CAMROL bearings are interchangeable dimensionally with standard CAMROL bearings. They are pre-lubricated and have a ferrous oxide finish to resist corrosion. Effective sealing against contamination reduces machine maintenance.

Camrol CYR series

In the CYR Series, an inner race replaces the stud for yoke or shaft mounting. Standard and sealed CYR bearings are available in the same stock sizes as CF and SCF Series.



SEND FOR MCGILL BEARING CATALOG NO. 52-A. for complete data on McGill CAMROL, GUIDEROL, MULTIROL and CAGEROL bearings.



SCHIELD BANTAM UTILIZES CF BEARING ADVANTAGES IN VARIETY OF APPLICATIONS.

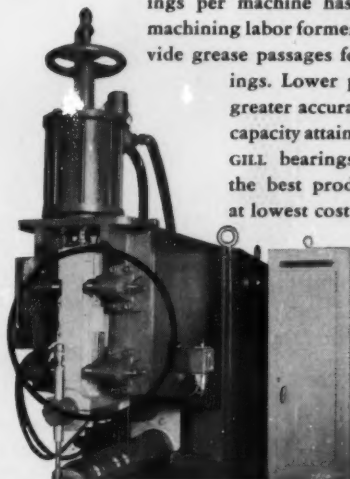
The Schield Bantam Company has applied CF bearings in internal clutch band operating arms, turn controls, swing and travel shaft clutch cones, engagement controls and speed shift collars. The photo above shows how CF-1 bearings are applied to Drum Clutches in Schield Bantam Series 350 cranes and shovels.

This company replaced bronze collars and yokes and reports cost savings through the use of CAMROL bearings. In addition they have increased capacity and have experienced improvement in length of life and maintenance factors. This has added to the over-all efficiency and dependability in heavy equipment where "down-time" is extremely expensive.

ACRO WELDER REDUCES PRODUCTION COSTS, IMPROVES ACCURACY WITH SCF BEARINGS

SEALED CAMROL bearings are used to accurately locate and guide the welding ram in spot welders made by ACRO

WELDER MFG. CO. The user reports that the use of 12 prelubricated CAMROL bearings per machine has saved hours of machining labor formerly needed to provide grease passages for unsealed bearings. Lower production costs, greater accuracy and high load capacity attained with these McGILL bearings help to assure the best product performance at lowest cost.



— insure precision performance in cam follower, track and guide roller applications



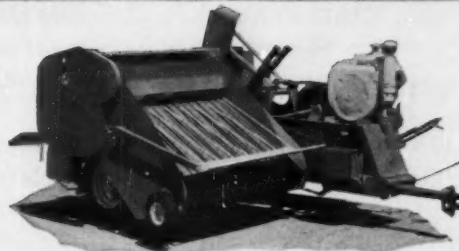
BUHR MACHINE TOOL CUTS FRICTION TO REDUCE HORSEPOWER WITH SEALED CAMROL BEARINGS

Production parts are drilled, milled, bored and tapped in automated systems engineered and built by the BUHR MACHINE TOOL COMPANY. The moving fixtures which hold parts being machined are guided and carried on McGill sealed CAMROL bearings as shown in the close-up above. By reducing starting and running friction to an absolute minimum, the CAMROL bearings have made horsepower requirement reductions possible in these systems. Ample load capacity, high resistance to shock loads and integral seals which retain lubricant and keep out contamination have held maintenance down. 8 SCF-3 CAMROL bearings guide and support each fixture.

engineered electrical products



precision needle roller bearings



J. I. CASE USES SCF AND SCYR CAMROL BEARINGS IN HAY BALER

The bale compressing plunger of the J. I. Case Model 177 Heavy Duty Hay Baler rolls on CF-2 $\frac{3}{4}$ -S CAMROL Bearings and CYR-1 $\frac{3}{4}$ -S Bearings guide the plunger.

Anti-friction bearing dependability and trouble-free performance are essential in this type of field equipment where bearing failure may result in loss of valuable harvesting time.

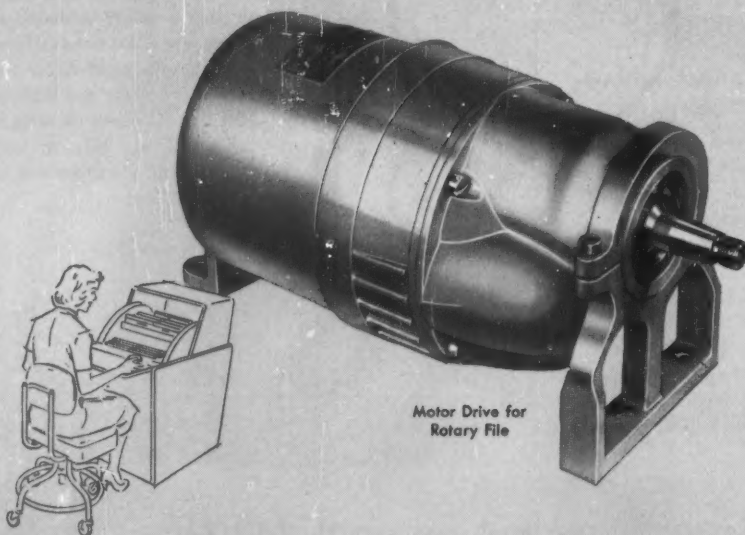
Integral bearing seals in these CAMROL bearings, keep re-lubrication requirements low and protect internal bearing components from field dirt, dust and moisture.

In addition to accurate, dependable action with minimum friction, high quality McGill CAMROL bearings offer savings on production and assembly.

MULTIROL-GUIDEROL-CAMROL-CAGEROL

MCGILL MANUFACTURING CO., INC., Bearing Division
200 N. Lafayette Street, Valparaiso, Indiana

Repeated Starts, Stops, Reversals Needed For This Motor Drive . . .



What Are Your Motor Requirements?

A business machine manufacturer came to us with this problem: he wanted a motor developed that would provide push-button operation for a rotary file in which thousands of records could be mounted on a large wheel.

Requirements for the motor were that it must be capable of repeated starts, stops and reversals . . . that it incorporate a special gear train that would assure quiet operation through many thousand hours of service . . . that it provide for quick and accurate stopping (accomplished with a magnetic brake).

Your motor requirements may be entirely different. But whatever they are, we will bring to the problem 44 years of widely diversified experience in the field of small motors to help you obtain the results you desire.

THE LAMB ELECTRIC COMPANY • KENT, OHIO

A Division of American Machine and Metals, Inc.

In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

Lamb Electric

SPECIAL APPLICATION
FRACTIONAL HORSEPOWER **MOTORS**



Actuator motor for automatic supermarket scale. Frame 2 1/2 x 1 1/2.



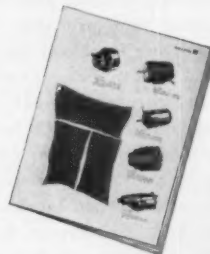
1/8 Horsepower motor with two-stage fan—the standard for high performance domestic canister-type cleaners.



Four-pole split phase motor with resilient cradle base for business machines. Frame 4 1/2 x 2 1/4.



110 Volt DC servo motor designed with maximum torque-to-inertia ratio for tape reel drive on computers. Frame 5 1/4 x 6.



Write for your copy...
8-page folder describes these and other Lamb Electric motors.



**in this zone,
stainless steels that
remain ductile with
high strength and stability**

In the search for favorable strength-to-weight ratio, high temperature alloys have been developed with extreme strength up to 1000 F, but at the expense of ductility.

In AM 350 and AM 355, Allegheny Ludlum's precipitation hardening stainless steels, you have high hardness and stability from room temperature to 1000 F, plus almost twice the ductility!

These advantages are followed by easy formability using normal techniques. AM 350 and AM 355 can be brazed and welded as easily as the common stainless steels. They can be spun, formed and machined without special preparation.

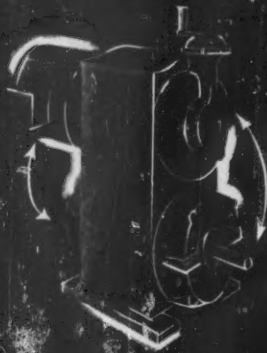
AM 350 is available commercially in sheet, strip, coil, small bars and wire. AM 355, best suited for heavier sections, is available commercially in forgings, forging billets, plates, bars, wire, sheet and strip.

For further information, see your A-L sales engineer or write for the new technical booklet, "AM 350 and AM 355." Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Penna.

ALLEGHENY LUDLUM

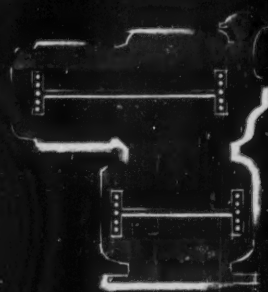
EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT





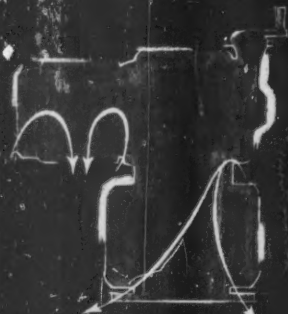
Field Versatility

Mounting feet, end brackets, control hand wheel, conduit box, and output shaft can be relocated in minutes without special tools for wall, floor, or ceiling mounting. Components can be changed or controls can be added in the field to meet ever-changing conditions of operation.



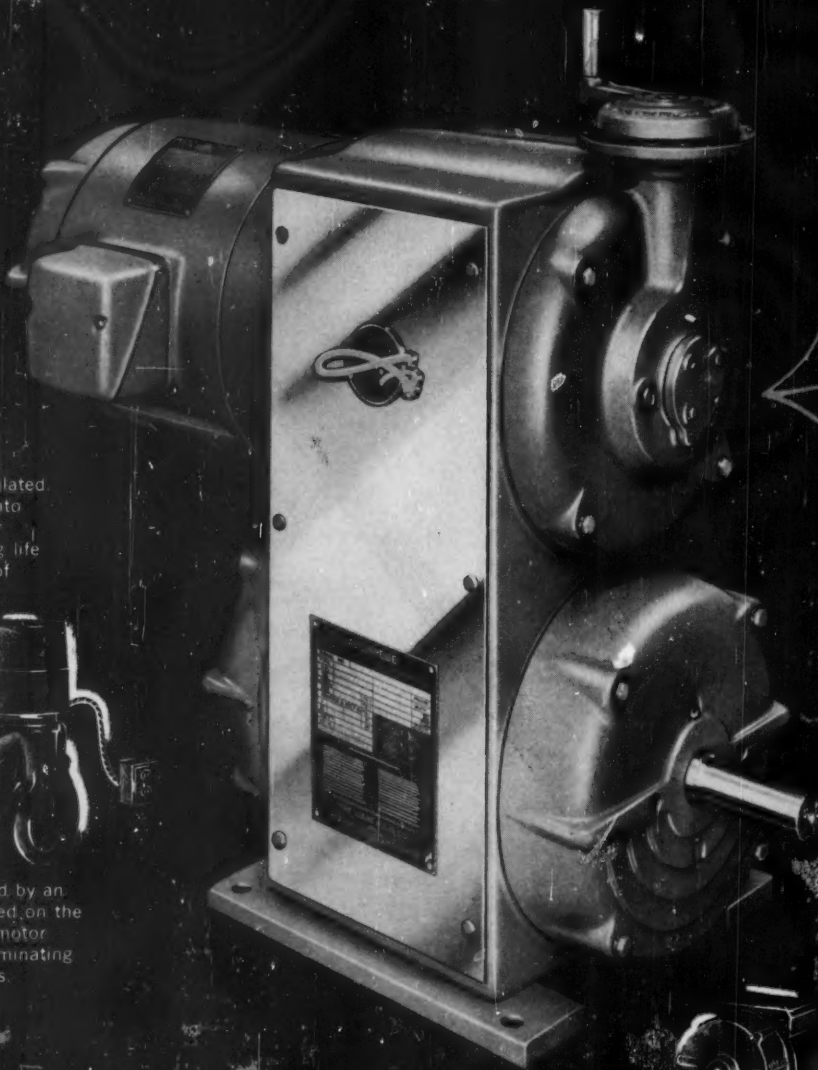
Four-Bearing Design

This important design feature eliminates the problems of overhung discs. It equalizes distribution of belt loading — keeps bearings, shafts, discs and belt permanently aligned — improves performance — and extends bearing life.



Dual-Ventilation System

The motor and the belt housing of the ALLISPEDE DRIVE are individually ventilated. Motor ventilating air is not exhausted into the belt housing — belts run cooler for longer life. Service factor and operating life of all components are higher because of lower operating temperatures.



Trouble-Free Remote Control

Electrical remote control can be provided by an enclosed speed adjusting motor, mounted on the belt changing mechanism. This torque motor can be stalled without overheating, eliminating the need for troublesome limit switches.

Long Belt Life

Single cog belts with extra contact area provide more efficient transmission of power and longer belt life. Dual ventilation, precision-machined discs, equalized loading, and automatic belt tension aid in extending belt life.



Fast Belt Changing

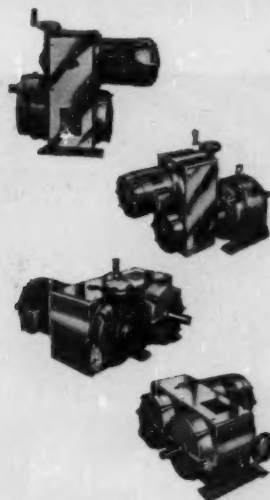
Belt changing is fast and easy — without requiring special tools. You remove only one bearing bracket and the speed adjusting mechanism to make fast changes without affecting permanent alignment of discs or belts.



Remote Speed Indication

A tachometer generator mounted on the output shaft operates an indicator that can be mounted at a remote location. Disassembly of the tachometer is not required when making belt changes.

Another new product from Louis Allis



Four of the many variations of mounting available with the ALLISPEDE DRIVE.

Let's look at the features of the **ALLISPEDE DRIVE***

New Louis Allis Drive offers accurate control — maximum belt life — long-run economy — low-cost versatility — ease of installation

The Complete Line—

Whatever your mechanical drive application requirements, there's an ALLISPEDE DRIVE to match it exactly. Sizes up to 30 HP, output speeds from 1 to 10,000 RPM, and speed ranges up to 8:1. Motors can be open, drip-proof, enclosed, or explosion-proof; with ventilated or enclosed belt housings, suitable for foot, P-base, C- or D-range mounting on your machine. Available with parallel shaft, or right-angle, integral gear reducers, special shaft extensions, integral magnetic brakes, electrical or mechanical remote control, and other modifications as required to meet the specifications of your application.

After checking the many superior features of this drive, you will prefer the Allispede every time. The illustrations at the left demonstrate the many advantages of design and construction available in this drive.

The Allispede Drive gives you high efficiency and close regulation. Belt tension adjusts automatically — and belt changes are easy and fast. The modern design eliminates overhung discs—maintains belt and disc alignment — results in longer belt life — provides the ultimate in field versatility.

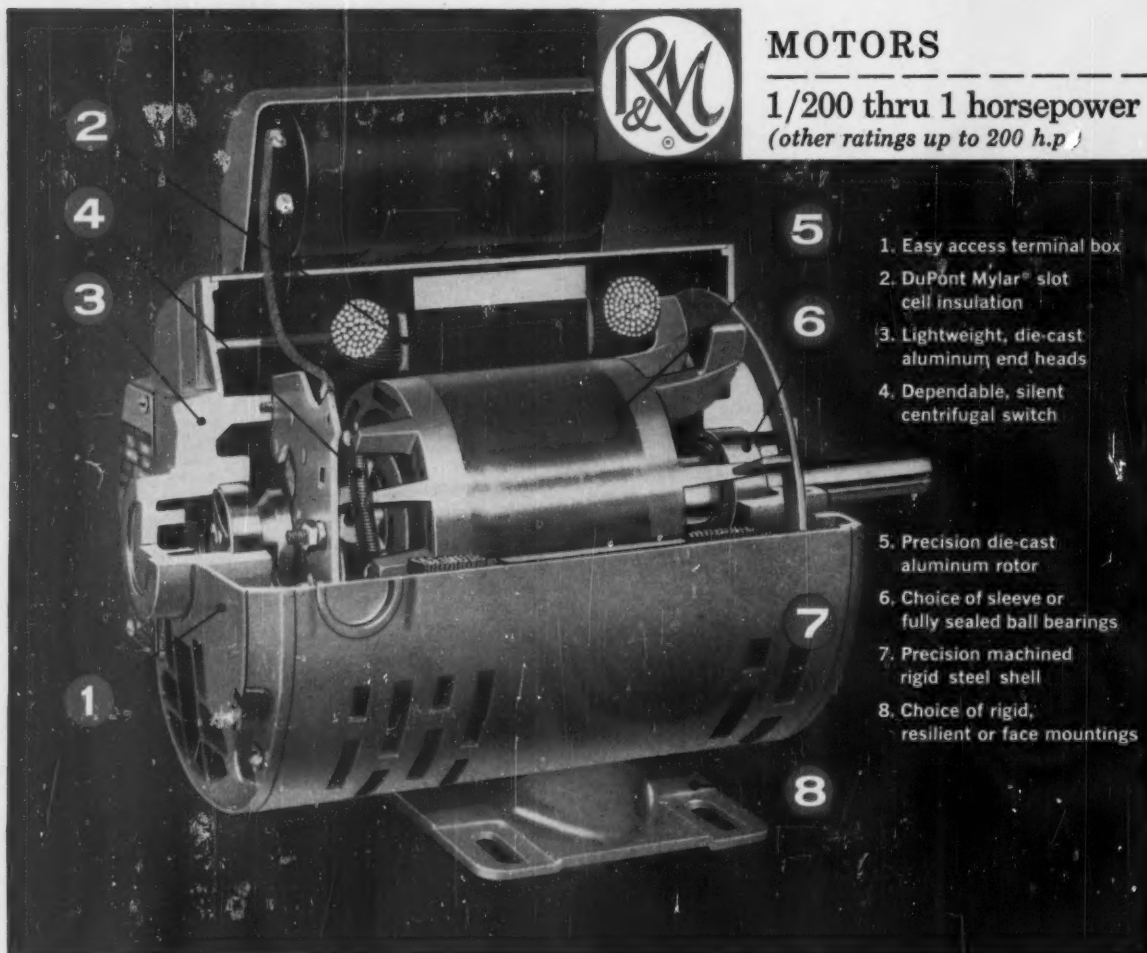
Check the accompanying features — *now!* A phone call to your local Louis Allis District Office will bring a skilled Louis Allis Field Engineer. He will gladly study your drive problem and offer Application Engineering assistance. Or write to Louis Allis Company, 459 East Stewart Street, Milwaukee 1, Wisconsin for a copy of Bulletin 3600.

*ALLISPEDE is a trademark of The Louis Allis Company.



MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS



R & M Fractional Horsepower Motors are packed with *Competitive Advantages* for your product!

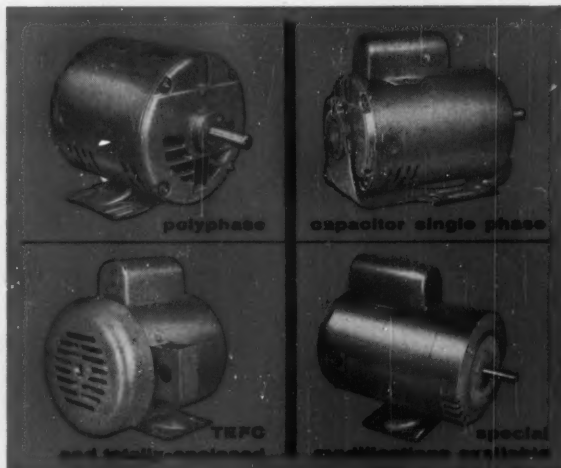
ROBBINS & MYERS "Model R" fractional HP motors, available in NEMA frames 56 and 48, are engineered and manufactured to give your product every possible competitive advantage so far as power is concerned. Each design detail results in superior performance and long trouble-free life, even under the severest operating conditions. They are smaller due to a more efficient ventilating system and lighter because of new applications of aluminum, steel and copper.

You have wider design versatility too, because they are available off-the-shelf in a broad choice of bearings, mountings, ratings, speeds and electrical characteristics.

These up-to-date design features, coupled with careful quality control at each manufacturing step, give you a modern motor you can rely on for all your powering needs. Also, if your needs indicate a custom designed motor Robbins & Myers welcomes the opportunity to discuss your quantity requirements.

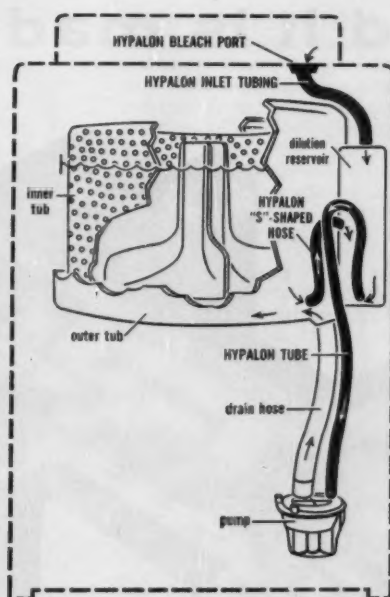
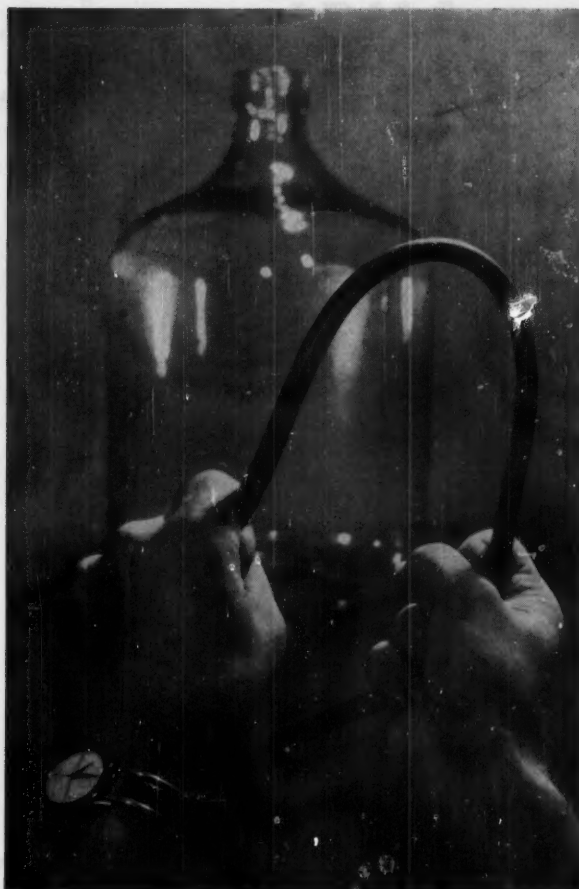
Learn all about the many advantages R&M motors offer you by writing today for Bulletin 450 MD

*DuPont registered trademark



ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps
SPRINGFIELD, OHIO • BRANTFORD, ONTARIO



MAYTAG TIMED BLEACH INJECTOR. Concentrated chlorine-type bleach is poured through the bleach port into the dilution reservoir. Here it is diluted four times by water from the tub. Diluted bleach is metered to the pump, and then delivered to the washer's outer tub. Within four minutes after the wash cycle begins, bleach reaches optimum concentration in the tub.

Maytag finds HYPALON® immune to chlorine bleach at 158° F.

Maytag had a good idea for their All-Fabric automatic washer. Why not design a timed bleach injector to automatically dilute and meter liquid bleach into the wash water? Then the housewife would have to add bleach only once...when she loaded the machine. Bleaching would be safe for fabrics, and wouldn't destroy the optical brighteners in detergents.

But there was a problem. To do this, they'd need flexible hose and tubing that could safely handle chlorine-type liquid bleaches. Maytag engineers tested hoses of several materials in 5¼% hypochlorite solution at 158° F. All hoses except one suffered damage within 24 hours. The

exception: a hose made of HYPALON, a Du Pont synthetic rubber. It remained unharmed even after a week's testing.

HYPALON was the solution—just as it has been for numerous other appliance design problems. For example, drain hose coated with HYPALON has proved to be color stable and impervious to ozone. On hermetically sealed compressors, HYPALON jacketing for lead-in wire has resisted temperatures to 350° F. To see how HYPALON can serve you, just write for a copy of our booklet outlining properties and performance. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MD-1, Wilmington 98, Delaware.

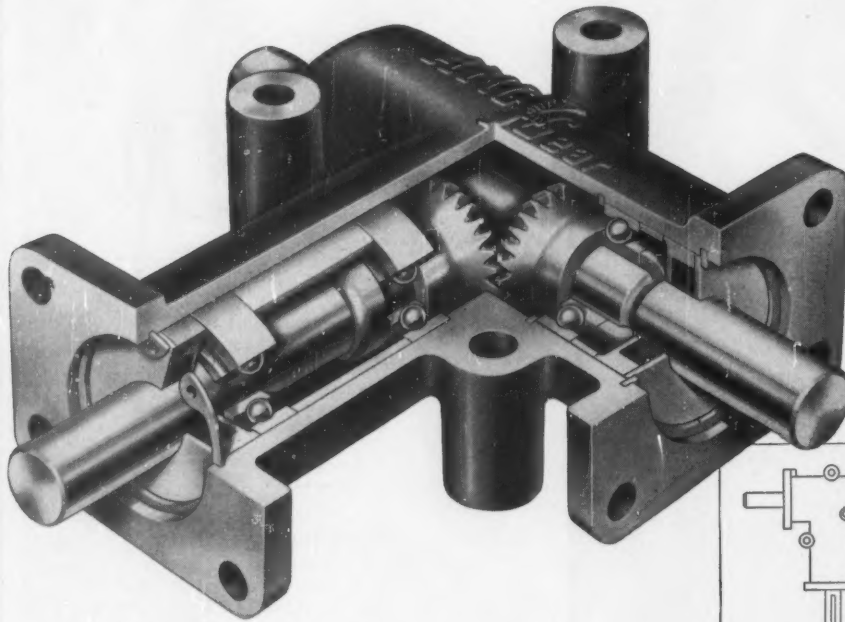


SYNTHETIC RUBBER

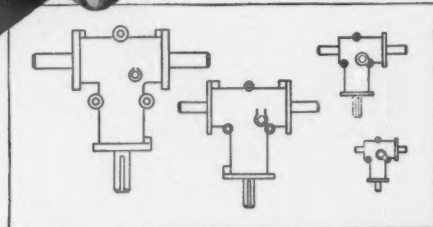
NEOPRENE HYPALON® VITON® ADIPRENE®

Better Things for Better Living . . . through Chemistry

There is only one ANGLgear®... and it is made only by Airborne



Quality of ANGLgear construction is evident in cutaway view. ANGLgear gives you all the features of other drives, plus greater hp range ($\frac{1}{2}$ to 5); permanent lubrication; and Coniflex® design gears for more even load distribution, reduced wear, quieter operation.



ANGLgear is available from local distributor stocks in 4 sizes, 16 models, with various gearing and shaft options.

ANGLgear—introduced in 1951—is the *original* standardized right-angle drive. It is also the No. 1 product in its field—in sales, availability, quality, performance. Witness the thousands of satisfied customers who have bought ANGLgear to date—for applications ranging from simple manual control of valves to classified installations aboard nuclear submarines.

In design and construction, ANGLgear has been refined to the point of being virtually foolproof, provided it is not grossly overloaded. Take a unit off the shelf, install it, run it—for years. Attention is seldom required.

Besides being maintenance-

free, ANGLgear is also easy to design into your power transmission systems because of its universal mounting feature. And it invariably costs less than other types of drives. ANGLgear is distributed nationally and is available immediately from local distributor stocks in the models listed here. Special sizes, special gear ratios, etc., can also be furnished. For complete engineering data, see our insert in Sweet's Product Design File, contact our local distributor, or write direct for new Catalog IA-58. *ANGLgear design template kits are available on request.*

*Trademark of The Gleason Works

BASIC MODEL DATA

Model	Type	Gear Ratio	HP	RPM Output Shaft	Ultimate Static Torque lb. in. Output Shaft	Shaft Dia.	Wt., lb.
R-300	2-way	1:1	1/3	1800	250	3/8	.5
R-300-2	2-way	2:1	1/5	1800	250	3/8	.5
R-310	3-way	1:1	1/3	1800	250	3/8	.5
R-310-2	3-way	2:1	1/5	1800	250	3/8	.5
R-320	2-way	1:1	1	1800	1000	5/8	2.2
R-320-2	2-way	2:1	3/5	1800	1000	5/8	2.2
R-330	3-way	1:1	1	1800	1000	5/8	2.4
R-330-2	3-way	2:1	3/5	1800	1000	5/8	2.4
R-333	2-way	1:1	2-1/4	1200	1500	3/4	8.7
R-333-2	2-way	2:1	2-1/4	1200	1500	3/4	8.7
R-335	3-way	1:1	2-1/4	1200	1500	3/4	9.0
R-335-2	3-way	2:1	2-1/4	1200	1500	3/4	9.0
R-340	2-way	1:1	5	1200	2500	1	14.5
R-340-2	2-way	2:1	5	1200	2500	1	14.5
R-350	3-way	1:1	5	1200	2500	1	15
R-350-2	3-way	2:1	5	1200	2500	1	15



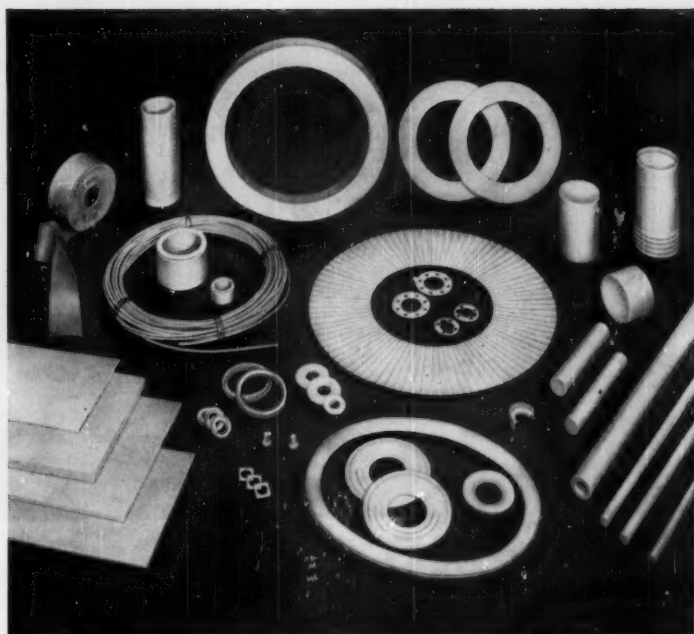
Engineered Equipment for Aircraft and Industry

AIRBORNE ACCESSORIES CORPORATION

HILLSIDE 5, NEW JERSEY



PLASTICS in Design Engineering



HOW TO SAVE TIME AND MONEY

Choose Garlock as *the* source for all your plastic needs. You'll benefit from Garlock's years of experience in injection molding, compression molding, extruding, punching, machining, and grinding of stock shapes and intricate parts. "Know-how" like this enables Garlock to recommend and furnish plastic materials *exactly* as you need them . . . without delay and at the lowest possible cost.

Garlock offers a wide selection of shapes and parts—regardless of size, tolerance, or quantity—in these engineered materials:

Teflon† TFE—contains the finest combination of chemical, electrical, and mechanical properties . . . chemically inert, outstanding electrical qualities, low coefficient of friction . . . withstands temperatures as low as -395°F , as high as $+500^{\circ}\text{F}$.

Nylon—guaranteed bubble-free . . . has high tensile and compressive strength, good resistance to heat and chemicals, solvents, oils and greases, retains toughness at temperatures ranging from -40°F to $+350^{\circ}\text{F}$.

Polychlorotrifluoroethylene (C.T.F.E.)—colorless, non-flammable . . . offers excellent dielectric properties, high compressive strength, resistance to chemicals, low cold flow in temperatures from -400°F to $+390^{\circ}\text{F}$.

Teflon FEP—combines the exceptional properties of Teflon with the advantage of being easily melt-processed . . .

Delrin†—offers metal-like strength and rigidity over a wide temperature range . . . **Polyethylene**—light, flexible, excellent electrical properties . . .

Polypropylene—lightest of all known materials.

Garlock will work directly to your specifications or, upon request, will gladly assist you in product design and development.

For complete information contact one of Garlock's 26 sales offices and ware-

GARLOCK

houses throughout the U.S. and Canada, or write for Plastics Catalog AD-171, The Garlock Packing Company, Palmyra, N. Y.

Canadian Div.: The Garlock Packing Company of Canada Ltd.

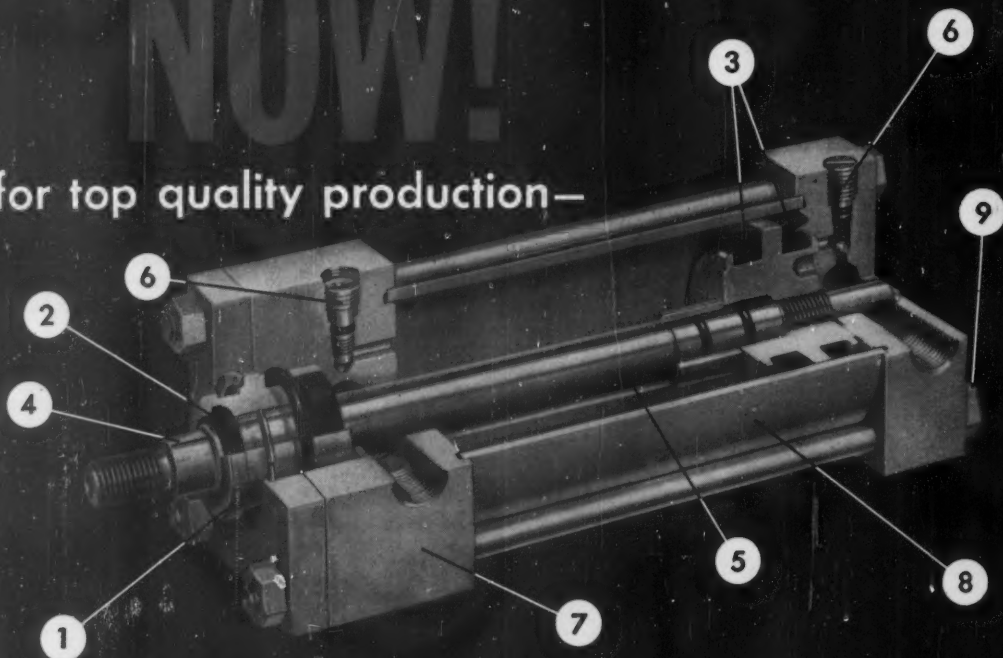
Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded & Extruded Rubber, Plastic Products

†DuPont Trademark

NOW!

for top quality production—



1. Bronze Bearing, with self-adjusting "U" Cup Piston Rod Seal for longer wear.

2. Rod Wiper protects Piston Rod Seal and keeps Cylinder clean.

3. "U" Cup Seals expand with pressure to provide positive seal with minimum friction.

4. Wrench Flats make for easy installation.

5. Ground, hard chrome-plated Piston Rods have minimum yield strength of 125,000 psi.

6. Self-locking cushion adjusting screw and ball check are below surface for protection . . . easily accessible.

7. For extra strength, Cylinder Ends and

Mounting Plates are machined from bar stock and steel forgings.

8. Cylinder is precision-finished brass for extra heavy duty.

9. Variety of mountings can be interchanged—easily match any installation requirement.

10. Interchangeable with all JIC Cylinders.

SCHRADER SQUARE-END CYLINDERS

meet and exceed JIC specs . . . 250 psi air . . . 750 psi hydraulic!

Here's compact, versatile straight-line power. Just look at the features!

Use Schrader's new square-end double-acting cylinders for holding, positioning, moving work—for push, pull or lifting—for automating manual operations. In five sizes up to 4-inch bore, and with five interchangeable mountings, these "square-ends" are economical and versatile. Bolt, leg, flush, side flush or base . . . each JIC Cylinder will mount all five ways. Suitable for air

pressures to 250 psi, or hydraulically to 750 psi—available cushioned or non-cushioned.

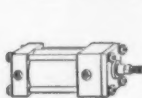
You get safe, controlled, low-cost power with Schrader "square-ends"—another addition to the line of famous Schrader quality Air Control Products.

Large stocks available at nearby Schrader Distributor—plus expert help to improve your air control circuits. Write for your complete specifications and data on these "square-ends."

Bolt Mounting



Leg Mounting



Flush Mounting



Side-Flush Mounting



Base Mounting



Schrader
a division of **SCOVILL**

A. SCHRADER'S SON
Division of Scovill Manufacturing Co.
476 Vanderbilt Avenue, Brooklyn 38, N. Y.

QUALITY AIR CONTROL PRODUCTS

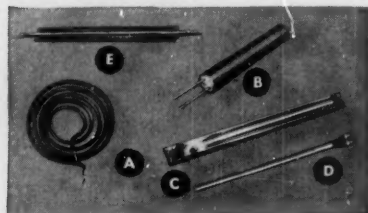


Surface Heating Guide

How to choose electric heaters of the right type and size for your design

Here is condensed information to help you get the most economical electric heater for your surface heating design problem.

Two factors generally determine which type heater should be used for any particular surface-heating application. They are: the physical characteristics of your product, and the surface temperature required.



General Electric *tubular heaters* (a) can be formed to unusual shapes and may be "cast in metal" as part of your product during manufacture. They may also be located in grooves, inserted into drilled holes, immersed in liquids, wrapped tightly around the surface or spaced away.

G-E *cartridge heaters* (b) are ideal for "spot" heating of small areas. Short and compact, they can be easily inserted into drilled holes within the machine or surface.

For flat metallic surfaces, such as hot plates, platens and dies, *strip heaters* (c) may be clamped on or spaced away. General Electric *insertion heaters*

TABLE 1—HEAT ABSORPTION IN KILOWATTS OF MATERIAL IN PROCESS

Volume of Material in Process (cu. in.)	Temperature Rise in °F					
	50	100	150	200	250	300
1	.006	.012	.018	.024	.030	.036
5	.030	.060	.090	.120	.150	.180
25	.090	.180	.270	.360	.450	.540
100	.360	.720	1.08	1.44	1.80	2.16
500	1.80	3.60	5.40	7.20	9.00	10.8
1000	3.60	7.20	10.8	14.4	18.0	21.6

This table is based on a ten minute working cycle. If working cycle is other than 10 minutes use following formula to correct values: 10 divided by the number of minutes in the

(d) are ideal for heating hollow bolts for high-pressure steam-shell joints to prevent steam leakage.

For warming tables, and preheating plates, G-E *vane heaters* (e) may be clamped on or spaced away.

To figure the amount of heat required for your application:

1. Find the volume in cubic inches of the material in process.
2. Figure needed temperature rise in degrees F (subtract initial temperature of material from desired final temperature).
3. Find heat absorbed by material (Table 1 applies to all materials except those listed in Table 2). Values from Table 2 should be added or subtracted from values in Table 1 to correct it.

TABLE 2 CORRECTION FACTOR

Material in Process	Subtract or Add % as indicated to figure in Table 3
Aluminum Dry	-30%
Wood or Paper Dry	-50%
Wood or Paper Wet	+20%
Glass	-40%
Rubber	-30%

cycle times the kilowatts given above equals the kilowatts at the new cycle. Table 1 will apply for all materials except for those listed in Table 2. Apply correction factor if needed.

4. Determine the total surface area of the platen.

5. Using this area and the desired final temperature, check Table 3 to get heat losses of platen.

6. Add kilowatts computed in Step 3 to those computed in Step 5. You now know how much heat is required.

For complete information on sizes and ratings of General Electric heaters, send coupon below.

DELIVERY TODAY: Popular sizes of General Electric heaters are available today from General Electric stocks near your plant.

SPECIAL SAMPLES: Your General Electric sales engineer can advise you on special heating problems. If special heaters are required, he will provide samples.

PROMPT SHIPMENT: General Electric's new Industrial Heating plant at Shelbyville, Indiana, is now geared to give excellent shipping dates on heaters for your production needs. Just call your nearest General Electric Apparatus Sales Office and tell us your requirements. General Electric Company, Schenectady 5, New York.

TABLE 3—PLATEN HEAT LOSSES IN KILOWATTS

Surface area of metal platens in sq. inches	Final temperature in degrees F of metal platens			
	100	200	300	400
100	.024	.080	.160	.280
250	.060	.200	.400	.700
500	.120	.400	.800	1.40
1000	.240	.800	1.60	2.80
2000	.480	1.60	3.20	5.60
3000	.720	2.40	4.80	8.40

*This table based on platens being completely uninsulated.

GENERAL  ELECTRIC

Section G723-12, General Electric Co.
Schenectady 5, New York
Please send GEA-6146, Surface Heating
Handy Selector Guide and GEC-1005,
Catalog of G-E Heaters and Devices.

NAME _____
COMPANY _____
ADDRESS _____
CITY _____ STATE _____

REPRODUCTION DEPT.



No More Costly Waiting like this for Engineering Prints ... Install automatic XEROGRAPHY!

Until recently, one of the most exasperating bottlenecks in industry was the time it took to get engineering drawings copied.

Lineups before reproduction windows were not only common, but chronic. The time of highly skilled . . . and highly paid . . . personnel was lost.

Now, a spectacular breakthrough



PUSH THE BUTTON...AND COPIES FLOW!

in the art of reproducing engineering drawings eliminates such waste.

Operating on the electrostatic principles of xerography . . . clean, fast, dry . . . a XeroX® Copyflo® printer—which enlarges, reduces, or copies size to size—automatically turns out prints up to 20 linear feet a minute. That's a print in seconds . . . dry, positive, ready for immediate use.

Just push the button . . . and copies flow! They may be on plain unsensitized paper, translucent vellum, or offset paper masters.

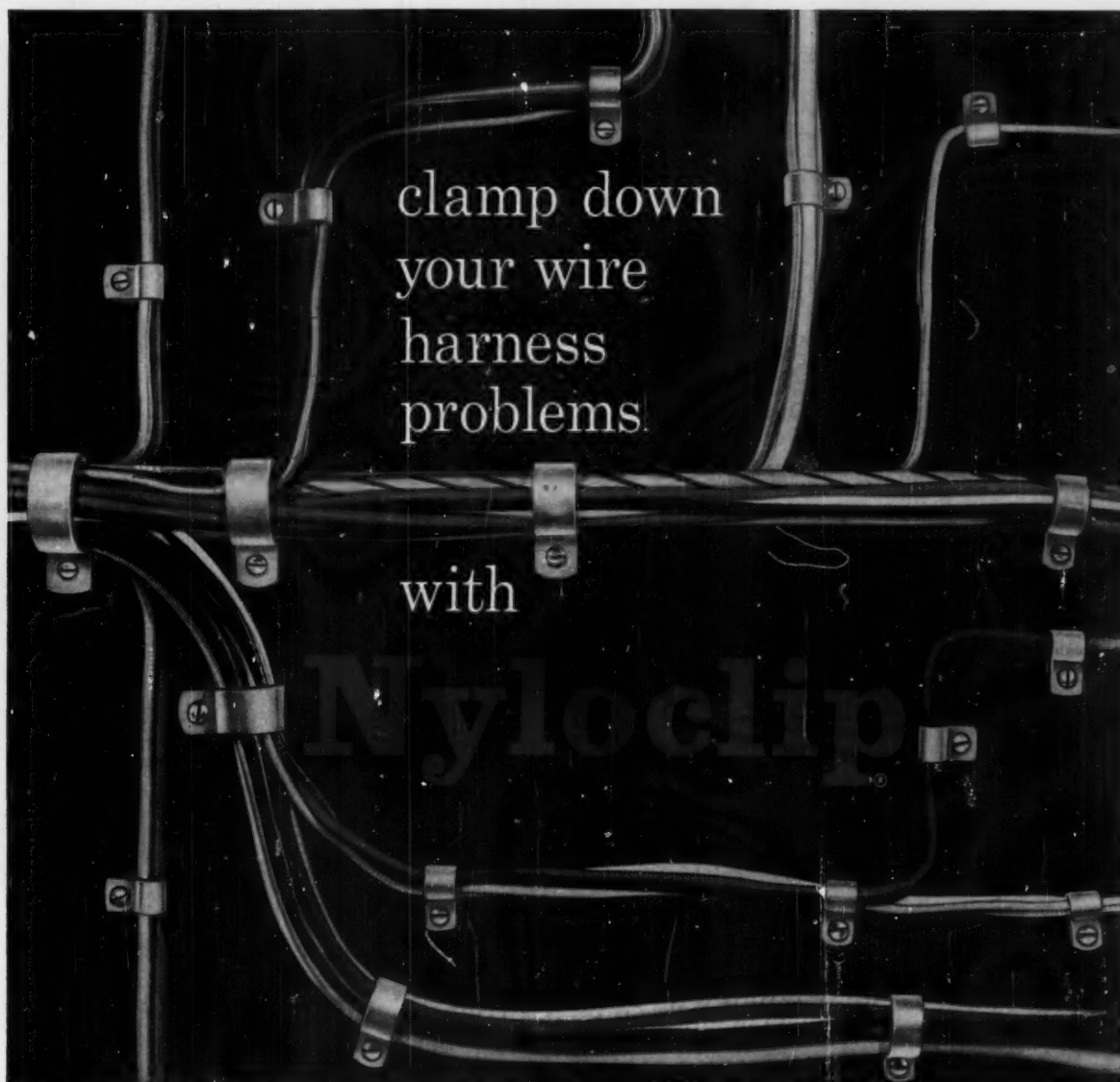
Combined with offset duplicating, a Copyflo continuous printer also makes feasible a stock-print system, in which multiple copies of drawings commonly used are run off in advance of need for self-service availability.

Prints are so inexpensive that engineers are urged to discard them rather than re-file them. Costs are cut dramatically, and savings from \$20,000 to \$100,000 a year are being reported.

A XeroX Copyflo printer offers the fastest, most flexible, most economical way to get copies precisely like the original from microfilm or original documents.

Write for Booklet X-287, containing complete information, HALOID XEROX INC., 60-109X Haloid Street, Rochester 3, N. Y. Branch offices in principal U. S. and Canadian cities. Overseas: Rank-Xerox Ltd., London.

HALOID XEROX®



clamp down
your wire
harness
problems

with

Nyloclip

...flexible molded nylon cable hangers that solve almost any problem in wire and cable support, whether it's **STRENGTH** (hold over 200 lbs.), **WEIGHT** (only 30% of comparable metal clips), **INSULATION** (will not ground or short), **ENVIRONMENTAL RESISTANCE** (withstand temperatures from 60°F to 250°F, oils, gasoline, other fluids), **PROTECTION** (fully protect cable insulation), **RANGE** (17 sizes for single cables or groups from 1/8" to over 2" diam.).

Get your free NYLOCLIP sample from OMATON DIVISION

BURNDY

NORWALK, CONNECT.

B.I.C.C. — Burndy, Prescott, Lancs., England • In Continental Europe: Antwerp, Belgium

TORONTO, CANADA

January 7, 1960

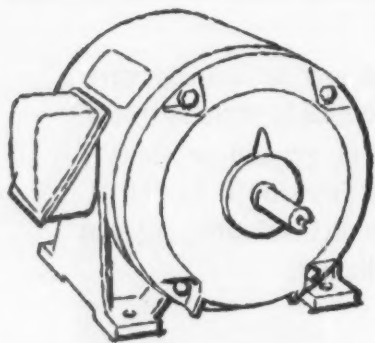
Circle 478 on Page 19

101



R. L. Potter, Sales Engineer, Pittsburgh District Office, Reliance Electric and Engineering Company.

"Think of your toughest motor job... then put Duty Master to work!"



"This a-c. motor stands up to the more extreme forms of industrial abuse . . . electrically and mechanically. It meets rugged duty cycles because of *built-in protection* . . . plus Reliance's ability to engineer the motor to any unusual application.

Electrical stamina . . . mechanical strength.

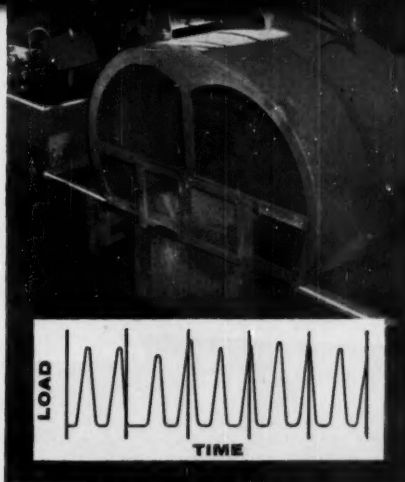
"The duty cycle curves demonstrate a wide range of rough applications that only a really good motor—Duty Master—can withstand over extended periods. The pictures reveal adaptability to modification and conversion. You can't beat proof that Duty Master's design can wholly meet special problems."

Duty Master is available now—¹/₂ hp. through 250 hp.

RELIANCE



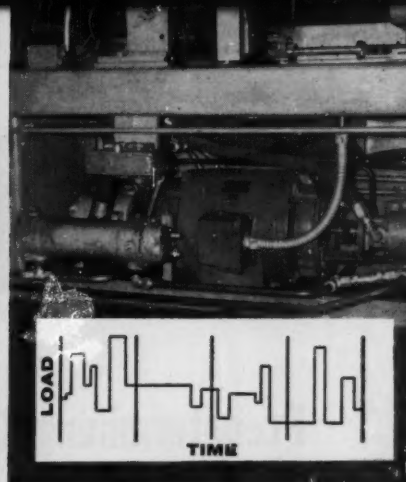
Duty Master
A-C. MOTOR



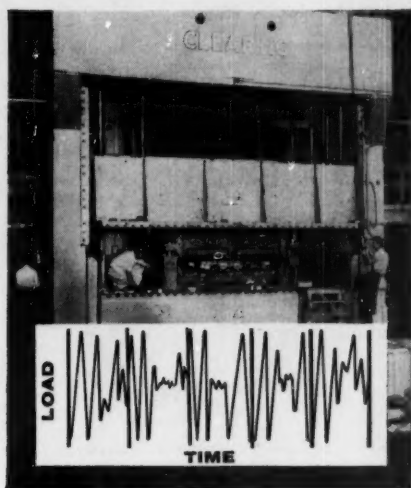
Hot Saw Motor: Duty Master powers a saw cutting 40 foot lengths of red-hot 4" diameter tubular steel moving at speeds up to 2000 feet per minute. Tremendous gyroscopic loads are exerted on bearings and rotating assembly by a rapidly circling saw arm. The motor is equipped with extra strength bearings, as well as a special oil mist lubrication system, in order to maintain continuous resistance to unusual operating pressures.



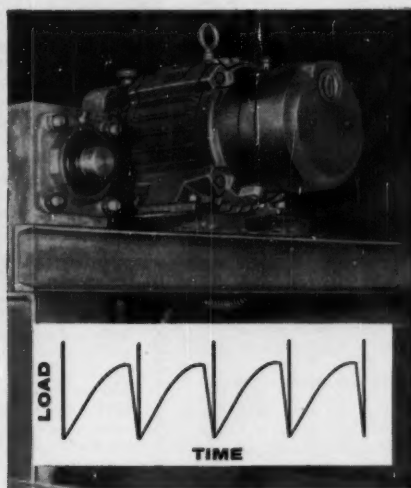
Furnace Fan Motor: Placed outside an annealing furnace, Duty Master uses a bi-metal shaft in driving fan inside. Bi-metal properties of the shaft reduce 2000°F. furnace temperature to bearing temperature. Special motor cooling design takes care of shaft expansion, supplies sufficient cooling to protect bearing adjacent to the furnace. Motor takes high overloads at the start due to low temperature air present as furnace begins operation.



Hydraulic Pump Motor: Injection molding machine shown is operated by a Duty Master close-coupled, double-end assembly. Necessary 25 hp. rating installed in limited space was accomplished using Class F insulation which permitted smaller frame size. Thus, this converted standard stock motor does the necessary job in a space which prohibited foot mounted pumps. Actually the unit cost is lower with this new application.



Press Motor: This powerful high torque, high slip motor accelerates to top speed and stops . . . in 4 seconds, and repeats the cycle 14 additional times in the same minute! Directly connected to the press action, this Duty Master Motor is insured against failure and downtime by better thermal storage capacity of the rotor . . . a new, efficient design feature.



Baling Motor: Reliance engineered the motor to the baling process, having established that previous applications were over-horsepowered under full load. A Duty Master 40 hp., 1800 rpm. motor runs continuously . . . is clutched and de-clutched to raise and position a weight in baling fixed tonnage of metal scrap. Motor leans into maximum load, is then released, as curve demonstrates.

The basic advantages of Duty Master stem from its sound design and engineering . . . from the inside out. Regardless of the ways in which you use this motor, Duty Master *will* perform . . . to your satisfaction.

Put Duty Master's protection, strength and convertibility to work for you. Reliance Sales Engineers can show you that, regardless of demanding applications, Duty Master pays off in long-term, dependable performance. We suggest also that you write for the new Duty Master Bulletin, No. B-2106.

B-1423

Product of the combined
resources of
Reliance Electric and
Engineering Company and its
Master and Reeves Divisions

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 281A, CLEVELAND 17, OHIO
Canadian Division: Toronto, Ontario
Sales Offices and Distributors in Principal Cities



Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V&S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.

Veeder-Root READOUT Bulletin

One of a Series

Predetermining Counters provide simplified methods for Automatic Control

Veeder-Root Predetermining Counters now make it possible to design and build automatic control into equipment of all types. They are available for mechanical, electrical and electronic control and offer many features and options to give your equipment extra value and versatility.

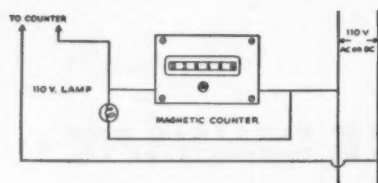
Predetermining Mechanical Counters can be applied to rotary, eccentric or stroke type motion, registering or counting whatever units are required — such as revolutions, motions, turns, pieces, lengths, and strokes. The newer electric and electronic Predetermining Counters use a special high speed light source and photo cell for non-contact counting on any machine or process.

Automatic control is provided by the predetermining counter actuating such devices as: lights, bells, signals and stop motions. They work at speeds up to 8000 counts per minute, can be easily incorporated into machine design and control panels. Application assistance is available from a Veeder-Root Counting Engineer; and specialized designs and modifications can be supplied in most cases. For complete information, call or write your nearest Veeder-Root office.

High Speed, Quick Reset Predetermining Counters for electrical and mechanical control, at speeds to 8000 cpm.

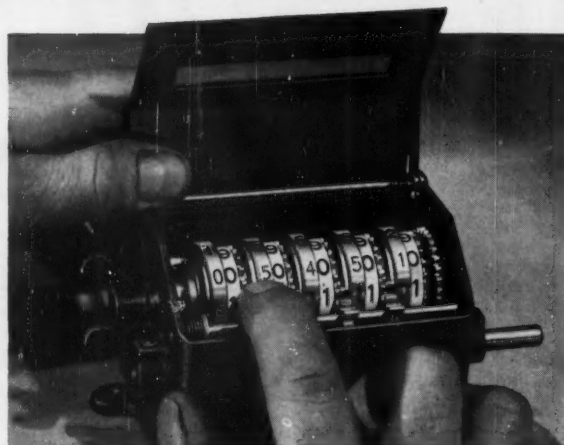


This counter has one set of wheels which are preset to any figure within the capacity of the counter by depressing the reset lever, raising the cover, and turning. The counter subtracts from the preset number to "00000", when a knock-off lever actuates an electrical switch. To reset, just press the reset lever, and counter returns instantly to preset figure. For Mechanical Control, counter actuates a mechanical lever instead of electrical switch. Speeds: 6000 rpm or 8000 counts per minute.



Addition of Magnetic Counter Provides Record of Total Lots.

A Veeder-Root Magnetic Counter connected in series with the alarm or stop motion registers one unit for each of the predetermined lots produced. Provides a simple means to obtain both machine control and production control.



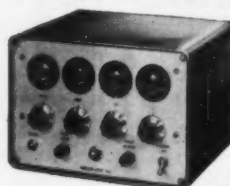
The High Speed Predetermining Counter is the basic counter in this complete line. It provides automatic control by this simplified method: ... to set a run of 5451 pieces on the counter: (1) Set all white wheels to zero with one turn of wing-nut; (2) Now, set the metal wheels, one by one. Set first wheel to "5", opposite zero on its "opposite number" white wheel, then set the "4", "5" and "1" and that's all ... you're ready to throw the switch and start the run.

Electric Predetermining Counter Ideal for Batching, Length Measurement and Materials Handling.

This new counter offers automatic reset plus other important features: **1.** Instant automatic reset ... Control contacts operate and hold for 0.3 seconds ... or for 2 seconds ... or indefinitely. **2.** Counter can be modified for automatic sequential predetermining, using two or more preset numbers. **3.** A batch or totalizing counter can be added. This counter is adaptable to material handling applications, slow speed batch counting, length measurement, slitting, and similar applications. Speeds up to 1000 cpm.



High Speed Electronic Predetermining Counters Feature Automatic Reset, 5000 cps.



The No. 1604 features instantaneous recycling. Up to six decade counters, with one, two, or more sets of preset numbers ... with or without photohead or enclosure. Output relay provides momentary or indefinite holding time. Batch totalizing available. Ideal for all high speed counting, up to 5000 cps, recycle at 1000 cps.

Send for Literature and Technical Data ... Extensive information and specifications on how to use Veeder-Root Predetermining Counters are yours for the asking. Send today.

Veeder-Root

HARTFORD 2, CONNECTICUT

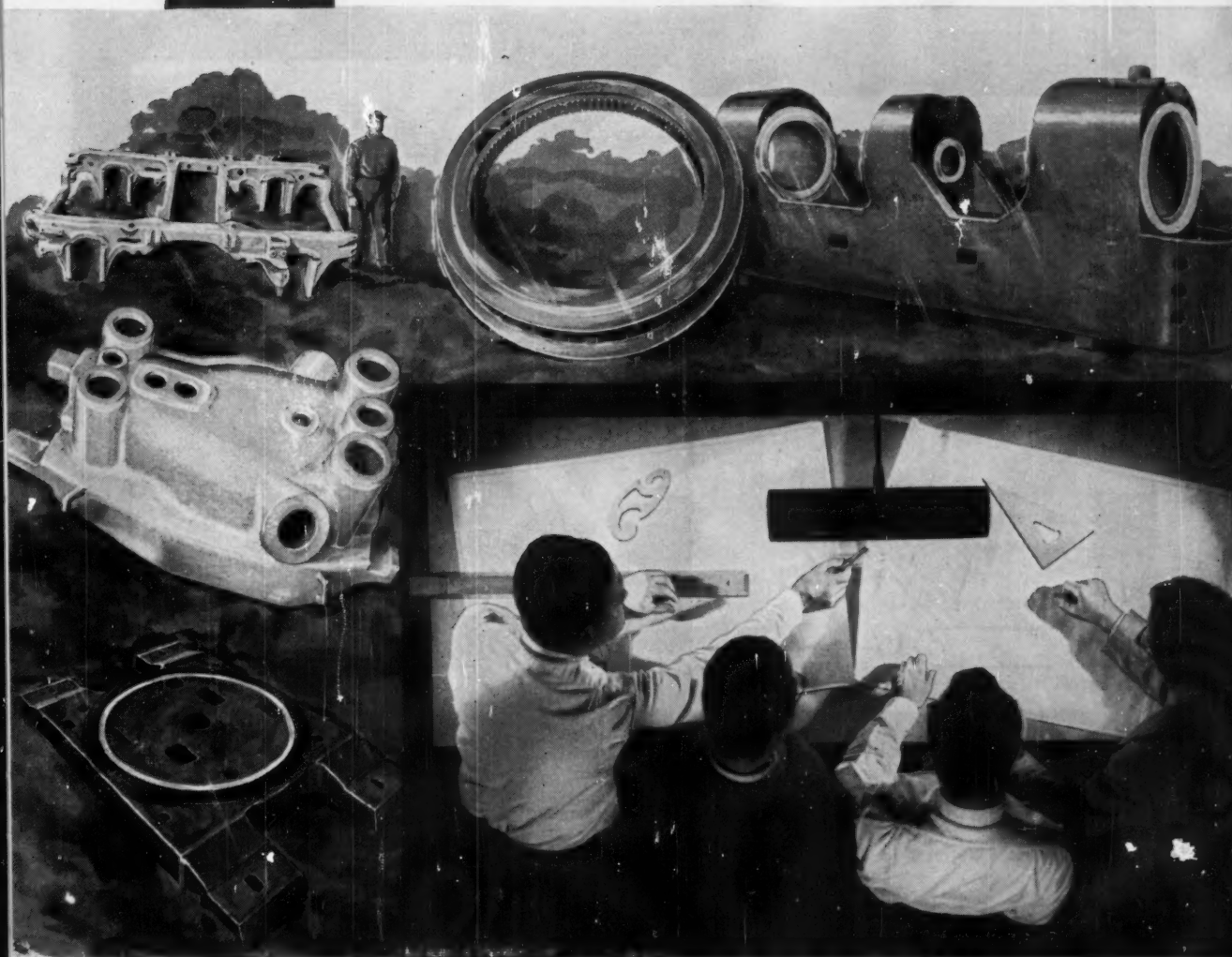
"The Name that Counts"

New York • Chicago • Los Angeles • San Francisco • Seattle
St. Louis • Greenville, S. C. • Altoona, Pa. • Montreal
Offices and Agents in other principal cities

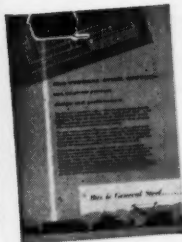




...where industrial progress is cast in steel



APPLICATION ANALYSIS...AS YOU LIKE IT



Write for folder:
**How General
Steel Castings
Can Improve
Product Design
and Performance.**
General Steel Castings
Station 260
Granite City, Illinois

A thorough analysis of application and design problems is necessary for the development of optimum structural designs. Experienced personnel . . . sales, engineering and manufacturing . . . drawing from General Steel's more than 50 years of experience, are fully prepared to evaluate the structural requirements of your product. Their recommendations will enable you to build a better product, taking full advantage of the many benefits to be gained through the use of steel castings.

General Steel works from your specifications, or better still, starts from scratch to help you plan components of your products whether they be cast steel, cast-weld or composite structures. Our complete service . . . a unique blending of research and development, creative design, quality production and follow-through in the field . . . complements the initial application analysis.

Whatever your present or future plans, let us show you what steel castings . . . and General Steel . . . can do for you.

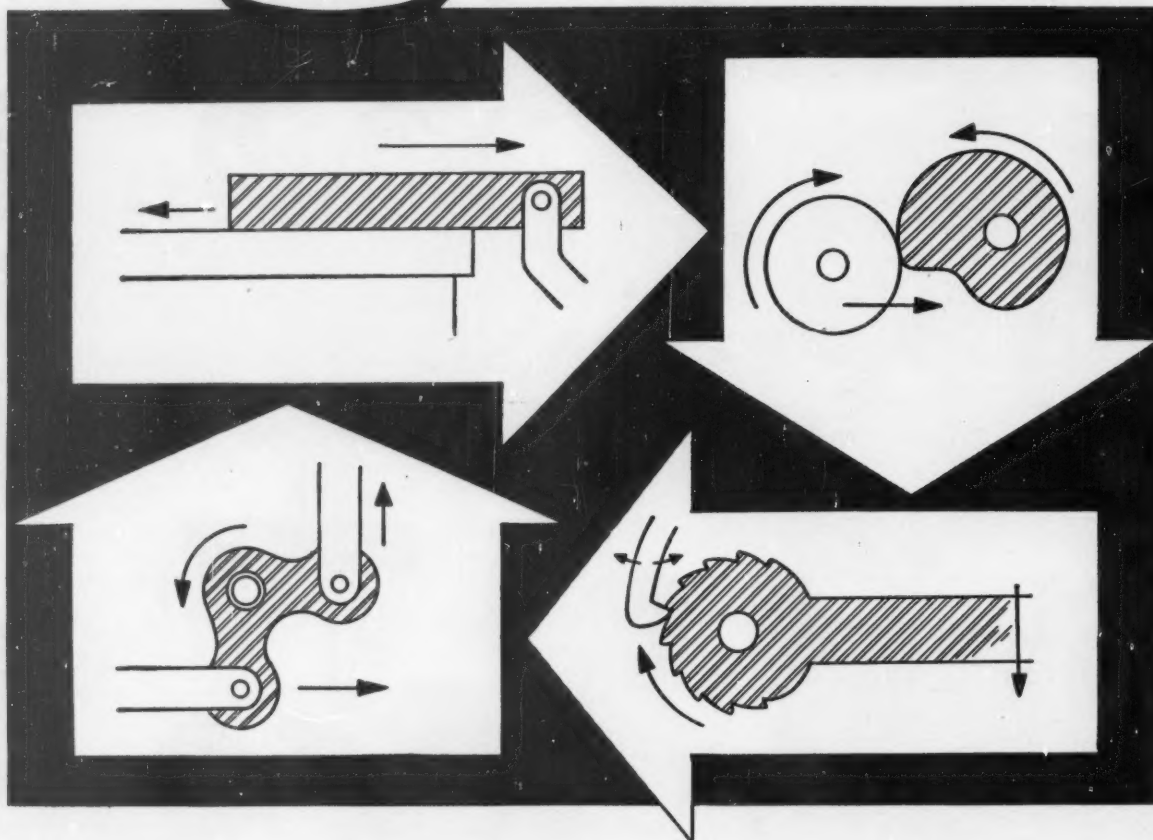
GENERAL STEEL CASTINGS

GRANITE CITY, ILL.

EDDYSTONE, PA.

AVONMORE, PA.

V-R METALS...



...for Design Wearability

If it slides on a surface . . . rolls on a shaft . . . makes interrupted contact . . . turns on a pivot . . . or performs any other function involving wear . . . you can rely on V-R metals to help solve your wear-part problems.

Extreme resistance to wear is just one of the valuable characteristics of metals that V-R makes available to the designer. It will also pay you to contact V-R whenever parts of your equipment require corrosion resistance . . . high density . . . stability at extreme temperatures . . . rigidity under a given load . . . good surface finish . . . and low coefficient of expansion for greater dimensional uniformity.

These properties can be produced in various combinations in sintered or alloyed metals to fill your specific needs . . . just send us the details of your requirements.



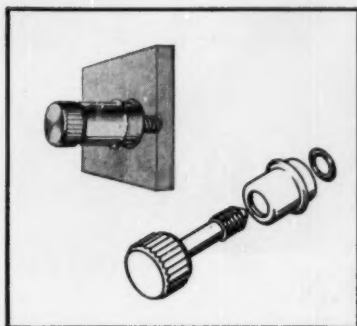
VASCOLOY-RAMET

CREATING THE METALS THAT SHAPE THE FUTURE

Compact Captive Panel Screws:

Standard Design Lowers Installed Costs

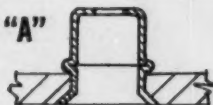
No longer is it necessary to resort to a costly fastening device of special design to provide quick attachment and release of electronic components. Standard Southco Retractable Screw Fasteners (stand-off thumb screws), available from stock, are both fast to install and economical. The five sizes,



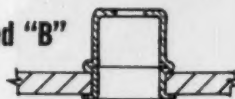
shown below, meet a very wide variety of requirements.

Check these advantages of simplified Southco Captive Panel Screws. Even when many screws are in one panel, misalignment is easily handled because the screw floats in a large hole in the stand-off, allowing ample play for "lining up." No special tools are

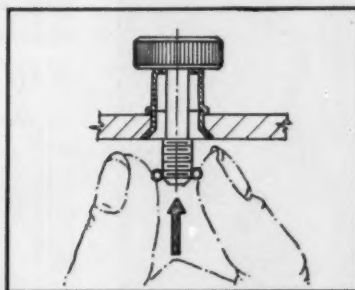
Method "A"



Method "B"



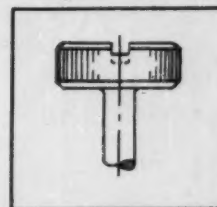
needed for installation, thus production is not subject to tool failure, nor limited by either the number of special tools available or the number of personnel trained in their use.



The Southco No. 58 Retractable Screw Fastener consists of three parts: thumb screw, stand-off, and retaining

ring. The bright nickel-plated brass stand-off is inserted in either a drilled and countersunk hole (Method A), or a drilled hole (Method B), and flared. The polished, chrome-finished brass screw is passed through the hole in the stand-off and made captive by a retaining ring. Engaging in a tapped hole in the frame, the screw may be fully withdrawn without moving the panel, yet always is retained.

The unslotted screw is standard in $\frac{3}{4}$ ", $\frac{9}{16}$ ", and $\frac{7}{16}$ " head diameters and three thread sizes. Slotted head screws are also available in all sizes. The stand-off is standard in sizes to fit panel thicknesses from a minimum of $\frac{1}{16}$ " to a maximum of $1\frac{7}{8}$ ". Screw and stand-off are also obtainable in stainless steel.

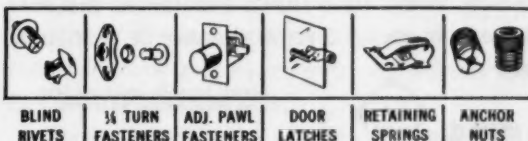


MINIATURE TO LARGE SIZE HEADS IN FIVE TYPES

HEAD DIAMETER	3/4"	9/16"	9/16"	7/16"	7/16"
THREAD SIZE	1/4-20	1/4-20	12-24	10-24	10-32

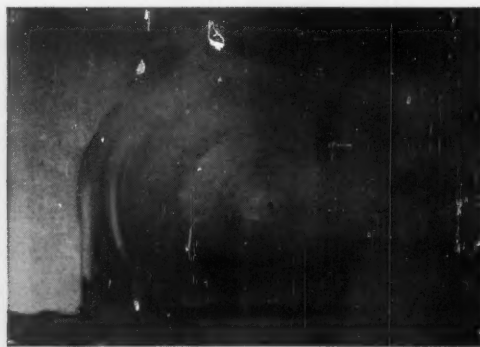
Free Fastener Handbook

Send for your complete Southco Fastener Handbook, just printed. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.



SOUTHCO FASTENERS
©1959
LION

PICKLED in a 4% brine solution!



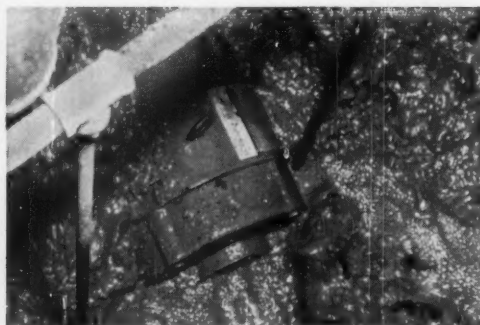
CHOKED

in a tornado of abrasive dust!



FROZEN

for weeks at 75° C below zero!



BURIED ALIVE

in thick, sluggish mud!

nothing . . . but nothing stops Super-Seal open-type motors

Thanks to exclusive Poxeal and Silco-Flex insulations, Super-Seal motors have shown endurances that even enclosed motors couldn't match. Results and reasons available from your A-C representative or distributor. Or write General Products Division, Milwaukee 1, Wisconsin

ALLIS-CHALMERS



A-1151

Poxeal, Silco-Flex and Super-Seal
are Allis-Chalmers trademarks.

Heavy Thrust Loads

Are a

PUSHOVER

for this

O-M Hydraulic (Oil)

Cylinder



SERIES TH

2000 psi Operation - 3000 Non-Shock

Available in 1 1/4" to 8" bores

Meets JIC Standards

MANY construction, design and engineering advantages contribute to the power-loaded thrusts of this heavy-duty O-M component. It is ruggedly constructed—all steel and bearing bronze. It is designed right to seal right against power loss. The large ports conduct an unrestricted flow of fluid to the piston, assuring full power. Cushion ball check valve provides for full power starts of return strokes.

The tensile steel, chrome-plated, standard or over-size, piston rods have a high yield point for higher load capacity. And the rod gland cartridge, threaded for easy removal, is piloted in rod head to assure perfect alignment undisturbed by heavy load stresses. In most installations, cartridge can be removed without removing mounts or tie-rod nuts. A complete selection of mounts is available.

Detailed information about these and other advance-

ments is contained in our latest Bulletin No. 105. Mail coupon below **TODAY** for your copy or consult your local O-M representative.

ORTMAN-MILLER MACHINE COMPANY
7 143rd Street, Hammond, Indiana



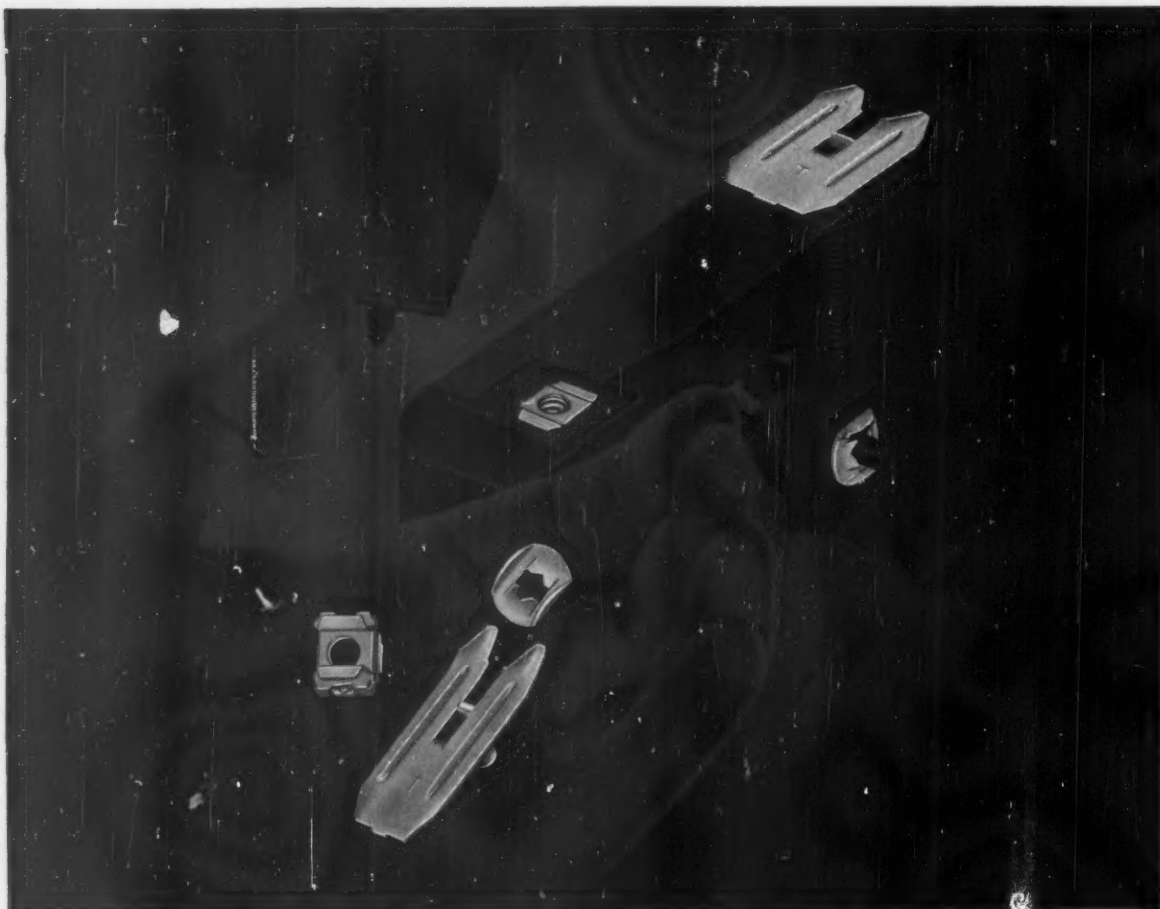
☐ Have representative call
☐ Send Bulletin 105

Name _____ Position _____

Company _____

Address _____

City _____ Zone _____ State _____



Assembly costs cut 50% at design stage by Tinnerman **SPEED NUT®** Brand Fasteners!

Fastener ideas worked out between designers at Hillside Metal Products, Inc., and Tinnerman engineers, resulted in the selection of 3 different SPEED NUT types for Hillside's complete line of quality steel office furniture. Hillside estimates "at least a 50% saving in material costs, assembly time and tooling" over ordinary fastening methods. And spring-steel SPEED NUTS hold tight, even through years of hard service.

A special Dart-Type SPEED CLIP® snaps into a punched hole, securely anchors one end of the drawer latching mechanism spring. A standard Push-On SPEED NUT "bites" into a stud; prevents the other spring end plus latching bar from backing off. Desk tops as well as desk and table legs, are attached with the help of SPEED GRIP® Nut Retainers that snap into bolt-receiving position in punched holes. A Push-On completes the file drawer follow block assembly; two more secure each filing cabinet drawer card holder.

This should give you an idea of what a free Fastening Analysis can probably do for you in savings and improvements on present or new products. Look up your Tinnerman representative in the Yellow Pages under "Fasteners". Or write to

TINNERMAN PRODUCTS, INC.
Dept. 12 • P.O. Box 6688 • Cleveland 1, Ohio

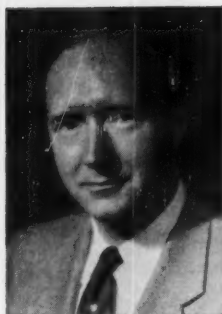
TINNERMAN

Speed Nuts®



FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Accessories Ltd., Treherest, Wales. FRANCE: Simmonds S.A., 3 rue Salomon de Rothschild, Sarcelles (Seine). GERMANY: Mecano-Buddy GmbH, Heidelberg.



The G.P. and the Specialists

OUR family doctor is as knowledgeable and competent as they come. But when confronted with a case a little out of the ordinary he is likely to say to his patient:

If I were the only doctor in a small country town, I would prescribe treatment here and now. But we are close to a fine medical center. Every specialty in medicine is represented by a man who is tops in his field. With your permission, let's use the best available resources and consult a specialist.

The design engineer is the general practitioner in his field. His special talent, and his principal value to his company, lie in his perception of the resources that will be needed to accomplish a successful design. While he is expected to cope personally with many engineering problems, he must also know where to turn for expert, specialized help.

That help may come from the manufacturers of components and materials that might be used in the new design. So he must know who makes what.

Help may be sought in the contributions of authorities to be found in books and engineering periodicals. So, keeping up with the literature is an integral part of his job responsibility.

In companies large enough to employ several specialists, the product design review committee approach offers another powerful aid in helping perfect a design. Elsewhere in this issue, A. M. Thomas tells how this plan works. In such a setup the design engineer's position parallels that of the family physician in a large city.

There is one possible pitfall in such an operation. Remember the remark about the camel being an animal that looks as if it had been designed by a committee? The design engineer has to see that the review committee doesn't get out of hand and end up designing a monstrosity.

The watchword is review rather than redesign.

Colin Carmichael

EDITOR

The Product Design Review

A. M. THOMAS
Design Specialist
Convair Div.
General Dynamics Corp.
Pomona, Calif.

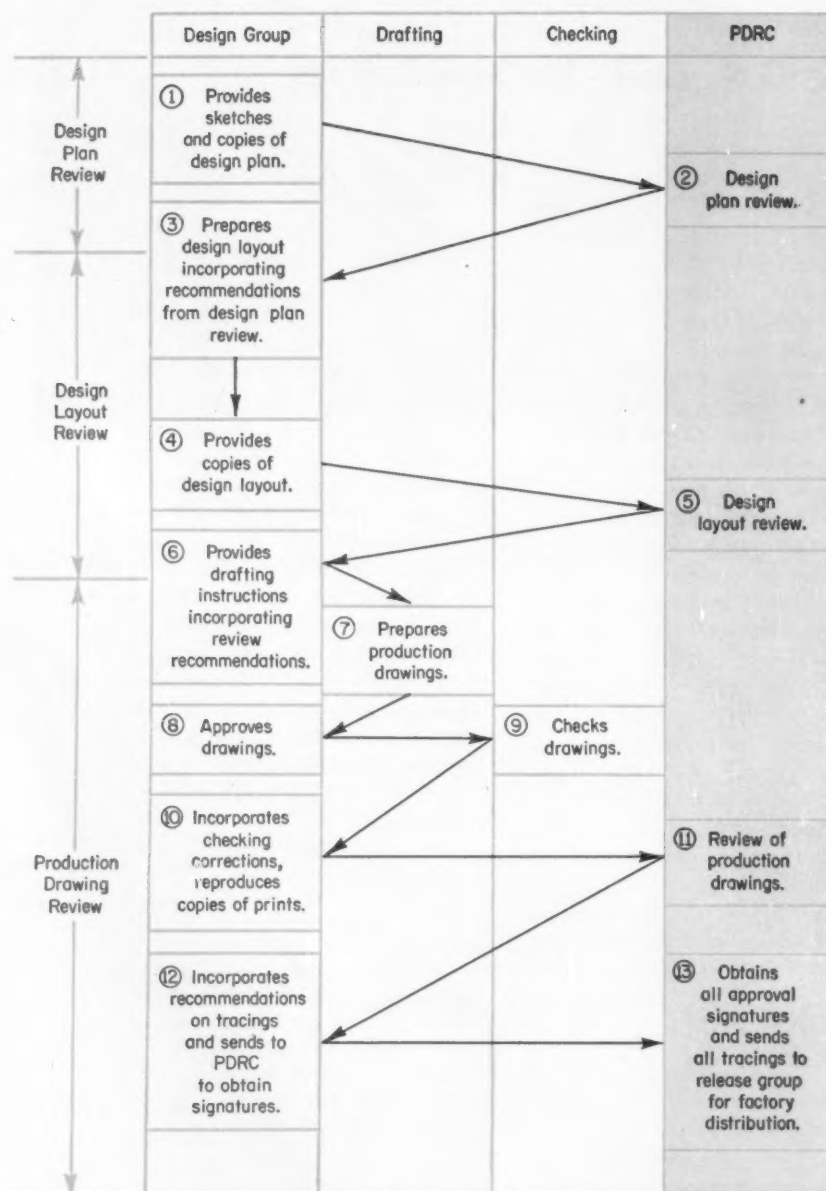
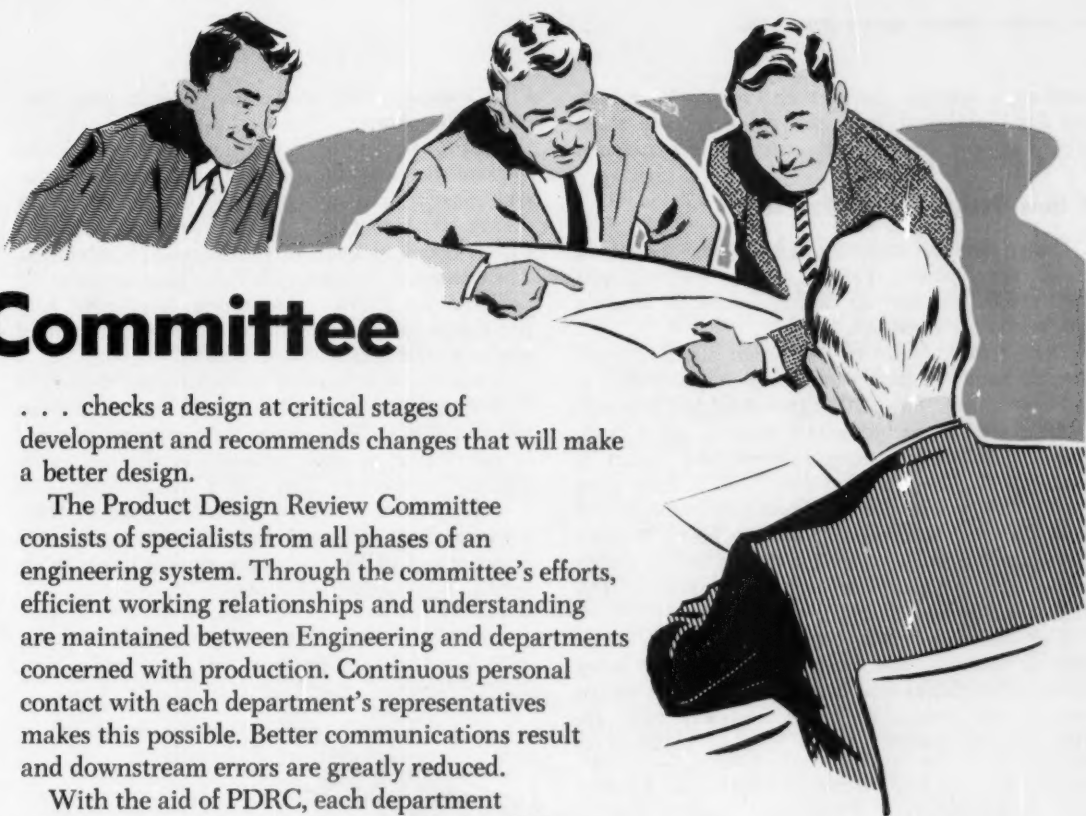


Fig. 1—Formal release of an engineering design, showing role of Product Design Review Committee.



Committee

... checks a design at critical stages of development and recommends changes that will make a better design.

The Product Design Review Committee consists of specialists from all phases of an engineering system. Through the committee's efforts, efficient working relationships and understanding are maintained between Engineering and departments concerned with production. Continuous personal contact with each department's representatives makes this possible. Better communications result and downstream errors are greatly reduced.

With the aid of PDRC, each department recognizes and gives consideration to other departments' problems. Problem areas can be forecasted and time allowances made.

As engineering systems become more complex, the designer finds himself relying more heavily on specialists—in production, processes, purchasing, tooling, quality control, and even in specialized phases of engineering design. A review of a product design by specialists, as the design progresses, contributes knowledge and experience that no one man could possess.

Of even greater value, over the long haul, are indirect benefits which result from planned operations that allow all departments to foresee and eliminate problems and difficulties. Such planned operations can be the work of a special committee—the Product Design Review Committee.

The Product Design Review Committee's goal is elimination of problems and difficulties. Some can be eliminated, some minimized and others can only be made known and allowances made for them. Getting problems out into the open where they can be attacked is the first step.

► What PDRC Does

Product Design Review Committee (PDRC) checks completeness, adequacy, and producibility

of released engineering designs and drawings. The committee creates a more efficient working relationship, improved communications, and closer understanding between: 1. Groups within Engineering. 2. Engineering and other departments.

PDRC reviews engineering designs prior to release and recommends improvements and necessary changes to the responsible design groups. Signed approval is given at time of release. PDRC reviews are in the form of recommendations and constructive suggestions, rather than in mandatory approval. Thus, most designers understand that they, and not PDRC, get credit for a good design.

In over three years of review operation at Convair, only one design was taken as high as the assistant chief engineer. PDRC felt that the design approach was unreasonable and would not approve it. Upon clarification of a misinterpretation of a customer requirement, the design was simplified considerably.

Qualifications of personnel selected for PDRC are presented in Table 1. At Convair, the PDRC chairman is a member of a group that is called Design Review and Value Engineering. The Design Group, Project Office and Design Review have technical

cognizance over the design with Project Office having final authority over the design. These three groups answer directly to the assistant chief engineer.

► How Design Review Proceeds

Design Review is performed at three points in design development, Table 2. These review points are: 1. Design plan. 2. Design layout. 3. Product manufacturing drawings.

During formulation of the design plan, all engineering members have a combined responsibility to assist designers. The PDRC chairman has responsibility to see that the designer is making use of available specialists and experts before the design is ready for its first formal review. This is done quite simply. He reviews published work assignments and work directives and then "pounds a beat." At least three times a week he makes rounds to the design groups and, with each supervisor's permission, contacts each designer.

The chairman works into the day-by-day engineering operation and sees the design as it is being made. If he thinks that any or all members should look at the design, he makes necessary calls. He also has responsibility to see that all members of

PDRC are apprised of the design as it progresses, usually by phone.

The time required for a formal review would be excessive without some advance familiarization and history of design progress. Continued review during the layout and design stages by individual PDRC members keeps final changes to a minimum. The completed drawings, after checking, are formally reviewed by PDRC. Continuous familiarity with the design plan and its layout reduces the third step to a minimum of time and effort.

When the designer has a design plan, layout, or drawings, he obtains prints or copies and delivers them to PDRC. This group distributes prints and/or information to other members of the committee, schedules a meeting, and directs the meeting. This is accomplished within a maximum time of three working days. At conclusion of the meeting, the designer and PDRC each have marked prints showing what changes will be made.



Fig. 2—Design Review "Feedback" suggests areas for design improvement.

**Table 1—Qualifications of Personnel
Selected for PDRC**

1. Engineering Dept.
 - a. Chairman—Design specialist preferably with fifteen to twenty years experience. Experience should cover most Design Groups and liaison with production departments.
 - b. Design Engineer—Engineer who prepared and is responsible for the design being submitted for review.
 - c. Project Engineer—Representative from the Project Office that has technical and budget responsibility for the project.
 - d. Checking—Representative from checking group that actually checked the drawings being submitted for review.
 - e. Materials & Processes—Experts on processes, manufacturing techniques and associated materials related to the design.
 - f. Other Engineering Dept. members as required—Specialists from dynamics, aerodynamics, thermodynamics, stress, or any other engineering group that the PDRC Chairman (or any member) feels could add constructively to design or explain questionable areas.
2. Materials Dept.—Specialist for guidance in economical materials selection, correct specification call-outs, and materials readily available.
3. Quality Control Dept.—Inspection expert who can guide the designer in keeping inspection equipment and methods costs at a minimum.
4. Tooling & Planning Dept.—Tool design, planning, and performance specialist who helps keep tooling simple and costs at a minimum.
5. Purchasing Dept.—Needed only when the design of a supplier is reviewed.

► Arbitration May Become Necessary

On occasion, arbitration becomes necessary when schedules, differences of opinion, or outside factors influence the design. If necessary, department heads discuss the differences and decide which course of action is most beneficial.

Poor communication or lack of communication cause misunderstandings. Good human relations thus become a prime consideration of the Product Design Review Committee; without it nothing could be accomplished. Respect for the professional pride and judgment of each member on the committee is most important and is easily justified. Each member was chosen for his knowledge, experience, ability to get along with others, and enthusiasm for the job.

Each committee member in his review of the design never asks *who* is right or *who* is wrong, but *what* is right or *what* is wrong. Design review does not only refer to evaluation of work that has been done, but of work that is to be done. The review points out areas that are questionable and areas that need improvement. Open discussion by the

committee in a group meeting resolves most problems or misunderstandings before they are reflected in the end product. Savings in time and money cannot be overemphasized.

► Specific Method of Design Review

A Product Design Review is performed by a systematic approach. Since a design breaks down into a complete drawing list from top assembly to the smallest detail, a review should follow the same breakdown. The top assembly gives a broad picture of over-all design. The balance of the drawings give details.

In the review of a design plan, Fig. 1, Step 2, an over-all approach or plan is presented, usually with a few sketches. Most of the major details are emphasized in a review of a layout, Step 5, and a complete picture can be given verbally. Of course, when completed drawings are submitted, a more detailed review is made, Step 11. Comments at each stage will include everything that could cause the production departments to request a correction, change, or clarification if released as is.

Looking at the over-all design there are three areas for consideration. Almost without exception these areas completely overlap one another and are interdependent. They are: 1. Completeness. 2. Adequacy. 3. Producibility.

Design is *complete* when all necessary information for manufacturing and inspection purposes is presented. Requirements must be completely spelled out on all drawings, since specifications for extreme environments, prolonged storage, and ever-increasing range and speeds constantly change.

Design is *adequate* if the information presented meets requirements and follows good company design practices. Exceptions occur when state of the art lags requirements. Requirements are sometimes idealistic, and by requesting temporary deviations, a design that is adequate can be obtained.

Design is *producible* if it can be produced with a minimum of difficulty, on schedule, and economically.

In a progressive company, the best of the old is combined with the new. Technical advances cannot be ignored, but should be evaluated and the best utilized. At Convair, technical memos as required and a periodic single page, *Design Review "Feedback,"* Fig. 2, suggest areas for design improvement. Typical subjects include repetitive discrepancies, designs that cause failure or confusion, continued expensive design features, or designs requiring expensive tooling or machining operations.

The art of preventing design errors requires more than original design ability. It also requires knowledge of processes, factory and tooling techniques, packing and assembly, and communication.

PDRC is after facts, not opinions—causes, not effect—reasons, not excuses. When these are determined, a review that produces better design results can be performed.

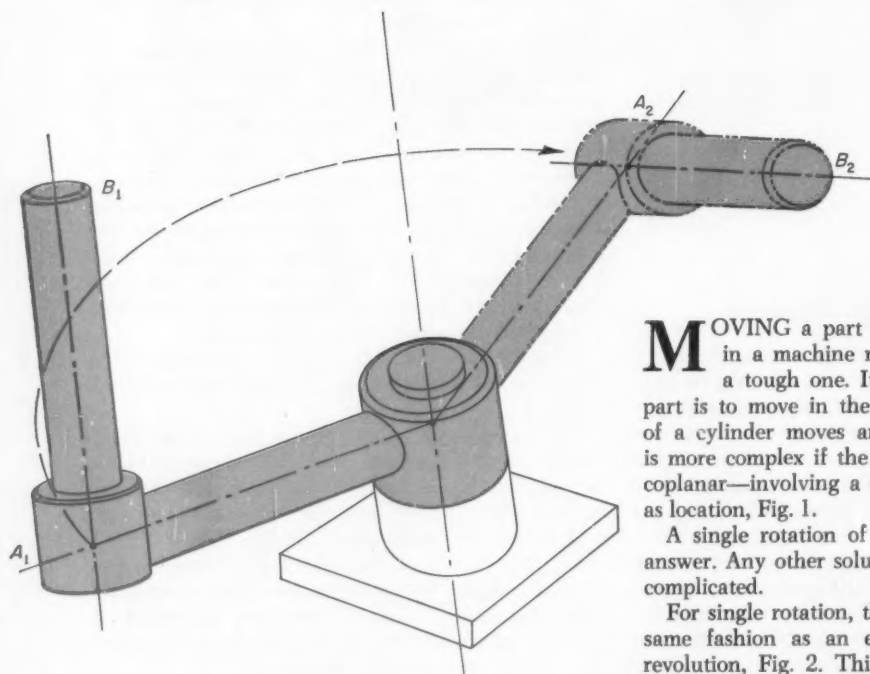
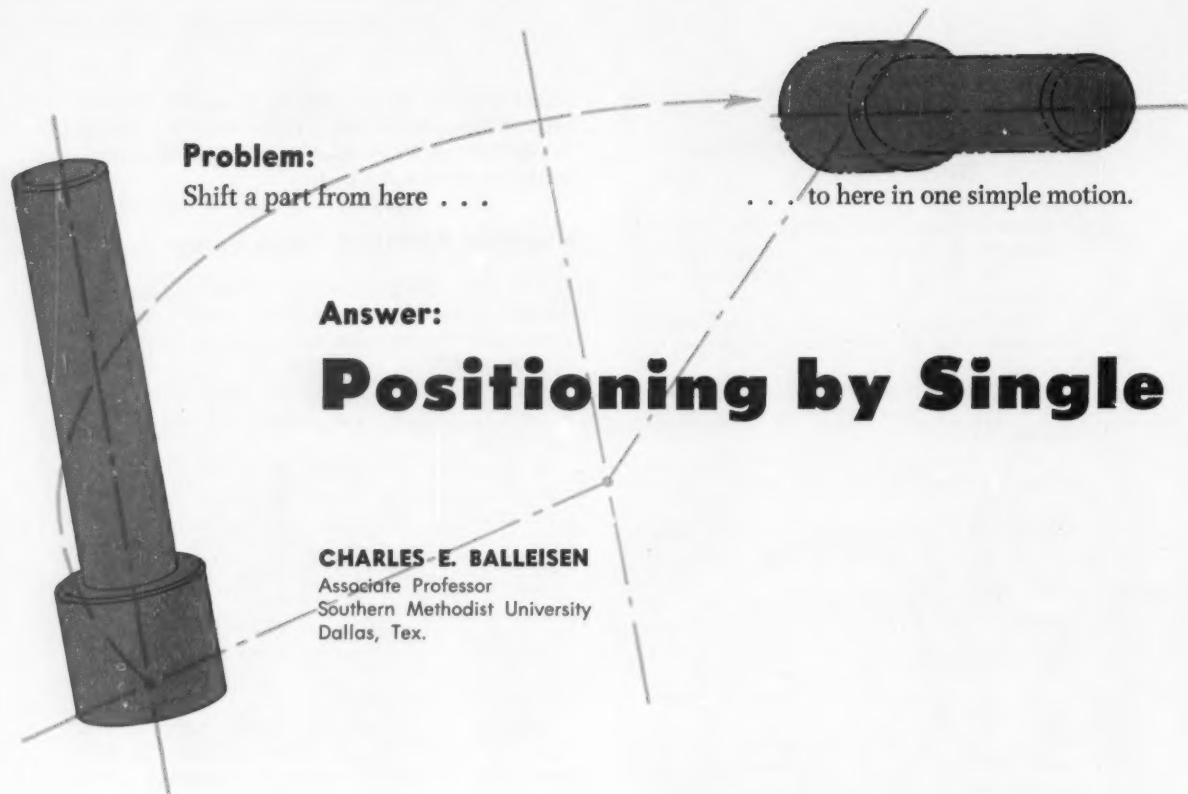


Fig. 1—Part positioned by a single rotation, as an element of a hyperboloid of revolution.

MOVING a part from one location to another in a machine may be an easy design job or a tough one. It's simple, for example, if the part is to move in the same manner as an element of a cylinder moves around the axis. The problem is more complex if the motion of the element is not coplanar—involving a change of orientation as well as location, Fig. 1.

A single rotation of the part would be the ideal answer. Any other solution would, perforce, be more complicated.

For single rotation, the part actually travels in the same fashion as an element of a hyperboloid of revolution, Fig. 2. This fact gives a basis for a rational solution. Since the problem does not yield easily to graphic procedures, the techniques of solid analytic geometry are best used. For this kind of movement there are exactly enough conditions to afford a solution. Once the positions are selected, the designer has no further choices of axis slope or angle of rotation.

To solve the problem:

Rotation

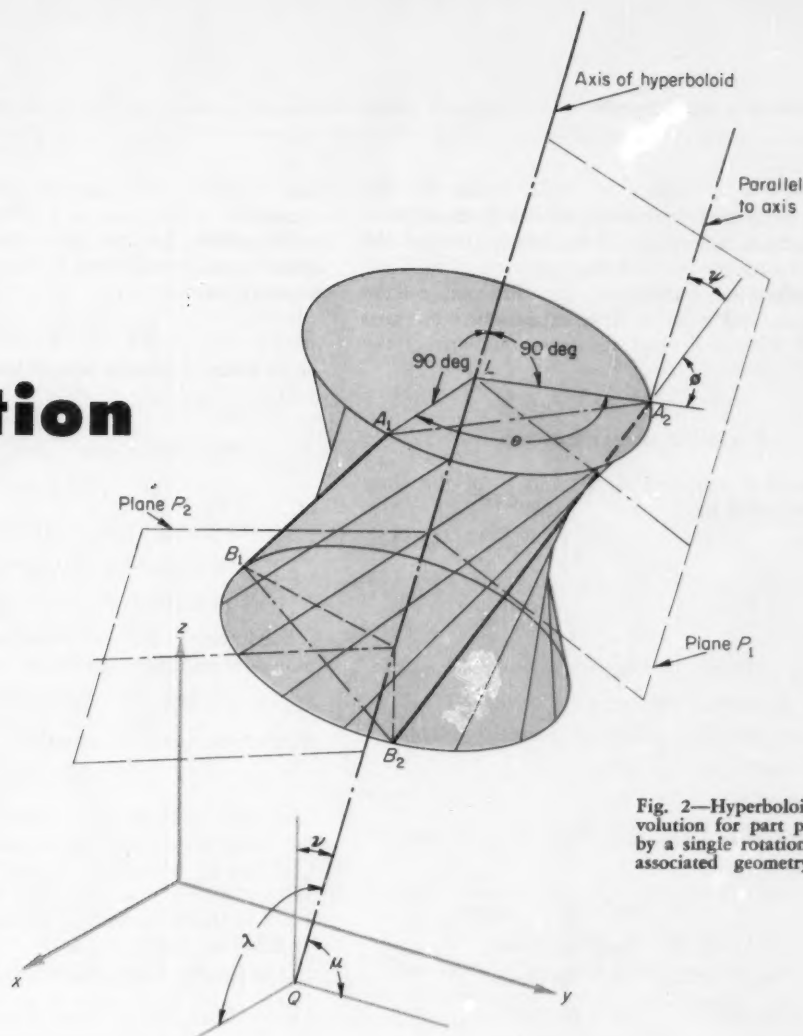


Fig. 2—Hyperboloid of revolution for part positioned by a single rotation, and its associated geometry.

1. Locate the axis of the hyperboloid.
2. Define a connecting arm from the axis to the part.
3. Measure the angle of rotation.

The procedure is most easily demonstrated with an example, Fig. 1. In one position, the centerline of a 5-in. shaft is positioned at A_1B_1 ; in the other it is at A_2B_2 . The axis of rotation does not lie in the same plane as the centerline of the shaft in either position.

Locating the Axis: First, locate the old and new shaft positions by right-handed, rectangular co-ordinates, Fig. 3. Starting conditions are the length, the co-ordinates of A_1 and A_2 , and the inclination of the shaft in the two positions. To locate B_1 let $z_{B1} - z_{A1} = \Delta z$, Fig. 4. Then,

$$(\Delta z)^2 + (\Delta z \tan 15 \deg)^2 + (\Delta z \tan 10 \deg)^2 = 5^2$$

and, hence, $\Delta z = 4.761$ in. Then, $\Delta y = -4.761 \tan 15 \deg = -1.276$ in. and $\Delta x = -4.761 \tan 10 \deg = -0.839$ in. Finally, co-ordinates of B_1 are:

$$\begin{aligned} x_{B1} &= 5 - 0.839 = 4.161 \text{ in.} \\ y_{B1} &= -1 - 1.276 = -2.276 \text{ in.} \\ z_{B1} &= 2 + 4.761 = 6.761 \text{ in.} \end{aligned}$$

Apply the same procedure to A_2B_2 to obtain the co-ordinates of B_2 (-1.452 in., 7.042 in., 7.471 in.). When the shaft is rotated, both A_1 and B_1 travel on arcs of circles, which form parallel planes, Fig. 2. Axis QL is the intersection of planes that bisect arcs A_1A_2 and B_1B_2 . These planes, P_1 and P_2 , are perpendicular bisectors of chords A_1A_2 and B_1B_2 .

The equation of plane P_1 bisecting line A_1A_2 , Fig. 4, is

$$\begin{aligned} \sqrt{(x-5)^2 + (y+1)^2 + (z-2)^2} \\ = \sqrt{(x+4)^2 + (y-3)^2 + (z-6)^2} \end{aligned}$$

which reduces to $18x - 8y - 8z + 31 = 0$. Similarly, with the co-ordinates just calculated for points B_1 and B_2 , the equation for the plane bisecting line B_1B_2 is $11.224x - 18.646y - 1.421z + 39.322 = 0$.

By simultaneous solution, the intersection of planes P_1 and P_2 is expressed as $y = 0.261z +$

1.4638 and $x = 0.560z - 1.072$. Since one coordinate of Q must be selected arbitrarily z_Q is taken to be 0, then, $x_Q = -1.072$ in., and $y_Q = +1.464$ in., thus fixing one point on the axis.

To determine inclination, the direction cosines of the axis, and a set of direction numbers are next obtained. Planes P_1 and P_2 have equations of the form:

$$a_1x + b_1y + c_1z + d_1 = 0$$

$$a_2x + b_2y + c_2z + d_2 = 0$$

The direction numbers A , B , and C of the shaft centerline are then

$$A = \begin{vmatrix} b_1 & c_1 \\ b_2 & c_2 \end{vmatrix} \quad B = \begin{vmatrix} c_1 & a_1 \\ c_2 & a_2 \end{vmatrix} \quad C = \begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix}$$

Solving,

$$A = \begin{vmatrix} -18.646 & -1.421 \\ -8 & -8 \end{vmatrix}$$

$$= (-18.646)(-8) - (-8)(-1.421) = 137.80$$

$$B = 64.22$$

$$C = 245.84$$

The direction cosines are

$$\cos \lambda = \frac{A}{\sqrt{A^2 + B^2 + C^2}} = \frac{137.8}{289.05}$$

$$= 0.4768 = \cos 61 \text{ deg } 32 \text{ min}$$

$$\cos \mu = 0.2222 = \cos 77 \text{ deg } 10 \text{ min}$$

$$\cos \nu = 0.8505 = \cos 31 \text{ deg } 44 \text{ min}$$

The axis can now be located, Fig. 4.

Defining the Connecting Arm: Point L , Fig. 2, is chosen so that angle $QLA_1 = \text{angle } QLA_2 = 90$

deg. In the actual machine, point A need not be connected to the axis at L . Point A merely serves to determine the line AL , whose angle of rotation must be computed. Point L is located by the Pythagorean equation,

$$\overline{QL}^2 + \overline{LA}_1^2 = \overline{QA}_1^2$$

or, in terms of specific co-ordinates,

$$(x_L - x_Q)^2 + (y_L - y_Q)^2 + (z_L - z_Q)^2 +$$

$$(x_{A1} - x_L)^2 + (y_{A1} - y_L)^2 + (z_{A1} - z_L)^2$$

$$= (x_{A1} - x_Q)^2 + (y_{A1} - y_Q)^2 + (z_{A1} - z_Q)^2$$

or,

$$(x_L + 1.072)^2 + (y_L - 1.464)^2 + (z_L - 0)^2 +$$

$$(5 - x_L)^2 + (-1 - y_L)^2 + (2 - z_L)^2$$

$$= (5 + 1.072)^2 + (-1 - 1.464)^2 + (2 - 0)^2$$

Substituting the relationships previously determined for points along axis QL ,

$$2.7649 z_L^2 - 9.5196 z_L + 0.65282 = 0$$

Solving this quadratic equation,

$$z_L = 3.373 \text{ or } 0.06819 \text{ in.}$$

The latter solution, $z_L = 0.06819$ in., does not check out when tested with the known positions of A and Q . Thus, $z_L = 3.373$ in. From the relationships previously determined, then $x_L = 0.560 (3.373) - 1.072 = 0.8291$ in. and $y_L = 0.261 (3.373) + 1.4638 = 2.345$ in.

The length of arm A_1L is found from

$$\overline{A_1L} = \sqrt{(x_L - x_{A1})^2 + (y_L - y_{A1})^2 + (z_L - z_{A1})^2}$$

$$= \sqrt{(0.8291 - 5)^2 + (2.345 + 1)^2 + (3.37297 - 2)^2}$$

$$= 5.5200 \text{ in.}$$

To check calculations, lengths A_1L and A_2L should

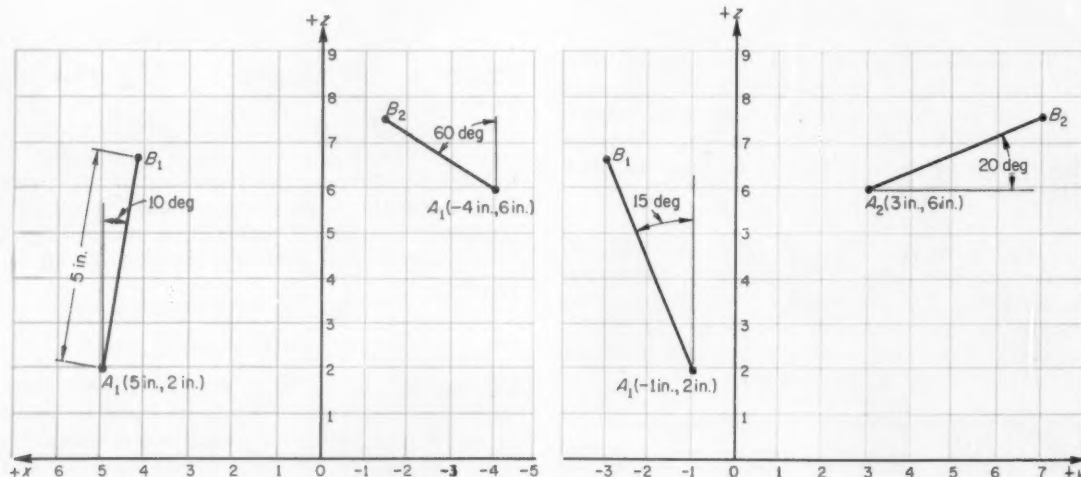


Fig. 3—Initial conditions of design, set up in rectangular co-ordinates, for a part to be positioned by a single rotation.

be calculated separately.

To orient the part with the arm, the angle ϕ between arm LA and shaft centerline AB is required, together with ψ , the angle between centerline AB and axis QL . Actually a third angle is needed to determine whether ψ is right or left handed. Often, this can be determined by inspection.

Using the cosine formula to find angle ϕ and proceeding from point A ,

$$\begin{aligned}\cos \phi (\overline{LA_1})(\overline{BA_1}) &= (x_L - x_{A1})(x_{B1} - x_{A1}) + \\ &\quad (y_L - y_{A1})(y_{B1} - y_{A1}) + \\ &\quad (z_L - z_{A1})(z_{B1} - z_{A1}) \\ \cos \phi (5.52 \times 5) &= (0.8291 - 5)(4.1606 - 5) + \\ &\quad (2.345 + 1)(-2.2757 + 1) + \\ &\quad (3.373 - 2)(6.761 - 2) \\ \cos \phi &= 0.209083 = \cos 77 \text{ deg } 56 \text{ min}\end{aligned}$$

To find ψ with the cosine formula, use only a section of the axis one unit in length:

$$\begin{aligned}\cos \psi (1)(\overline{B_1A_1}) &= \cos \lambda (x_{B1} - x_{A1}) + \\ &\quad \cos \mu (y_{B1} - y_{A1}) + \\ &\quad \cos \nu (z_{B1} - z_{A1}) \\ \cos \psi (1)(5.5201) &= (-0.8394)(0.4768) - \\ &\quad (1.2757)(0.2222) + \\ &\quad (4.761)(0.8505) \\ \cos \psi &= 0.6097068 = \cos 52 \text{ deg } 26 \text{ min}\end{aligned}$$

The determination of ϕ and ψ will lead to two possible angular positions, which can usually be separated by reference to a model or the layout.

Measuring the Angle of Rotation: This angle is the angle θ between arm positions A_1L and A_2L . To find θ , always proceed in the positive directions of both lines; that is, from A towards L . General expression for this calculation is,

$$\begin{aligned}\cos \theta (\overline{LA_1})(\overline{LA_2}) &= \cos \lambda_{LA1} \cos \lambda_{LA2} + \cos \mu_{LA1} \cos \mu_{LA2} + \\ &\quad \cos \nu_{LA1} \cos \nu_{LA2}\end{aligned}$$

or, the following equivalent equation can also be used:

$$\cos \theta \sqrt{(A^2 + B^2 + C^2)(D^2 + E^2 + F^2)} = AD + BE + CF$$

where

$$\begin{aligned}A &= x_L - x_{A1} & D &= x_L - x_{A2} \\ B &= y_L - y_{A1} & E &= y_L - y_{A2} \\ C &= z_L - z_{A1} & F &= z_L - z_{A2}\end{aligned}$$

From this equivalent form,

$$\begin{aligned}\cos \theta (30.470479) &= (0.8291 - 5)(0.8291 + 4) + \\ &\quad (2.345 + 1)(2.345 - 3) + \\ &\quad (3.373 - 2)(3.373 - 6)\end{aligned}$$

where

$$\begin{aligned}\sqrt{(A^2 + B^2 + C^2)(D^2 + E^2 + F^2)} &= (\overline{LA_1})(\overline{LA_2}) \\ &= 30.470479\end{aligned}$$

Solving,

$$\cos \theta = 0.851300 = \cos 148 \text{ deg } 21 \text{ min}$$

Checking: As a guard against errors, the calculations should always be checked against the original conditions. To assist in visualization as well as in checking, a model of plywood or cardboard is invaluable.

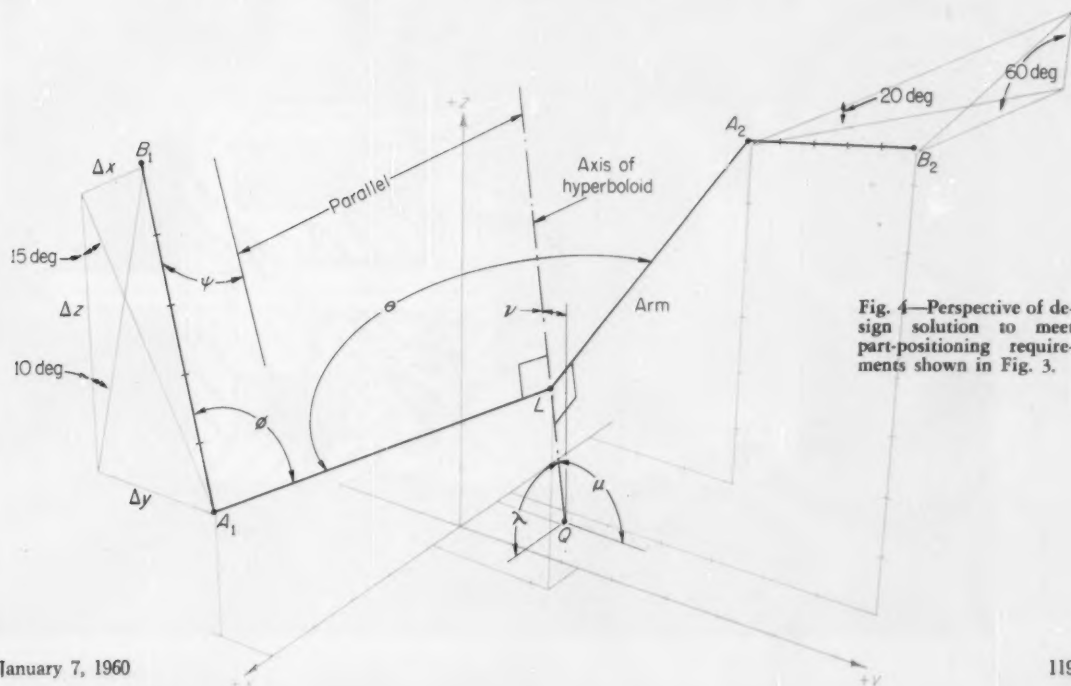
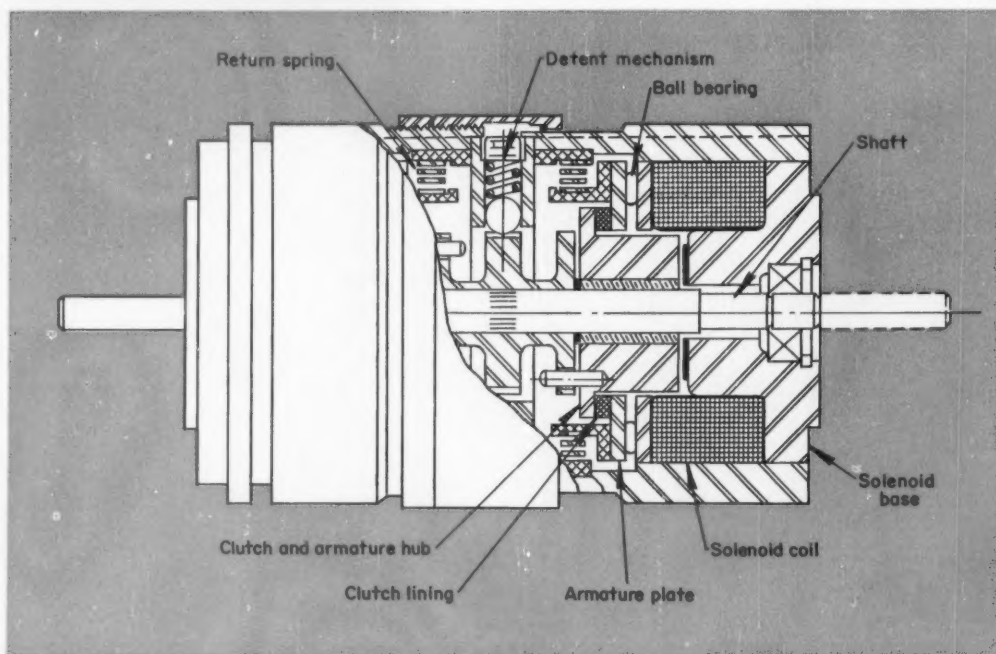


Fig. 4—Perspective of design solution to meet part-positioning requirements shown in Fig. 3.

scanning the field for *ideas*

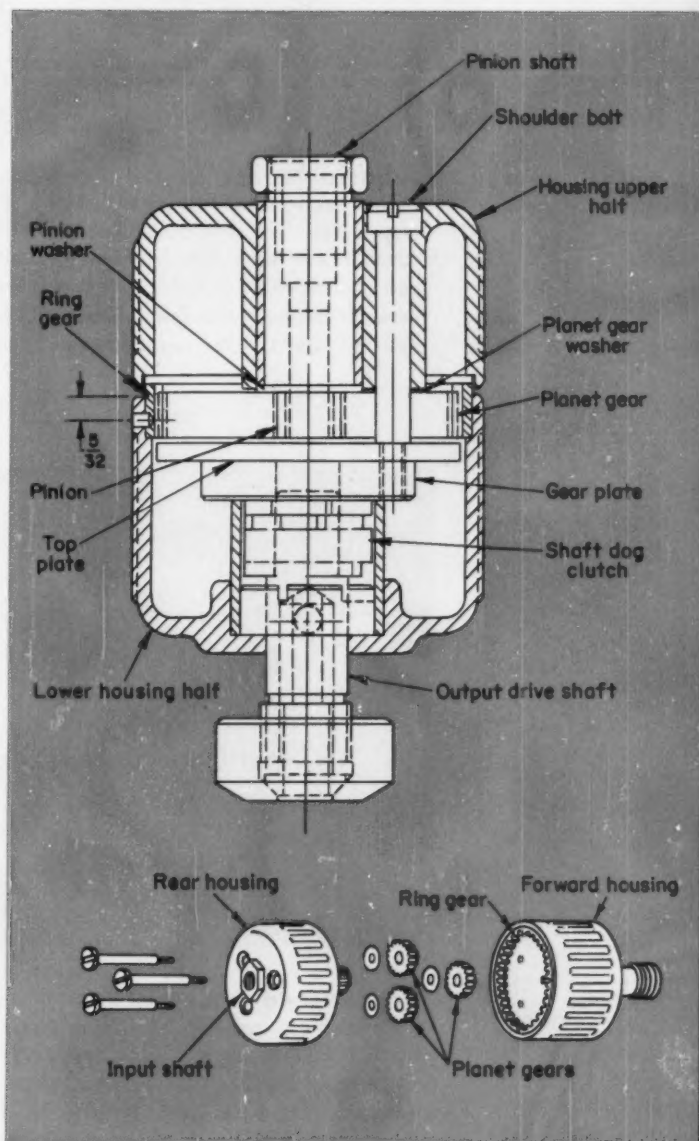


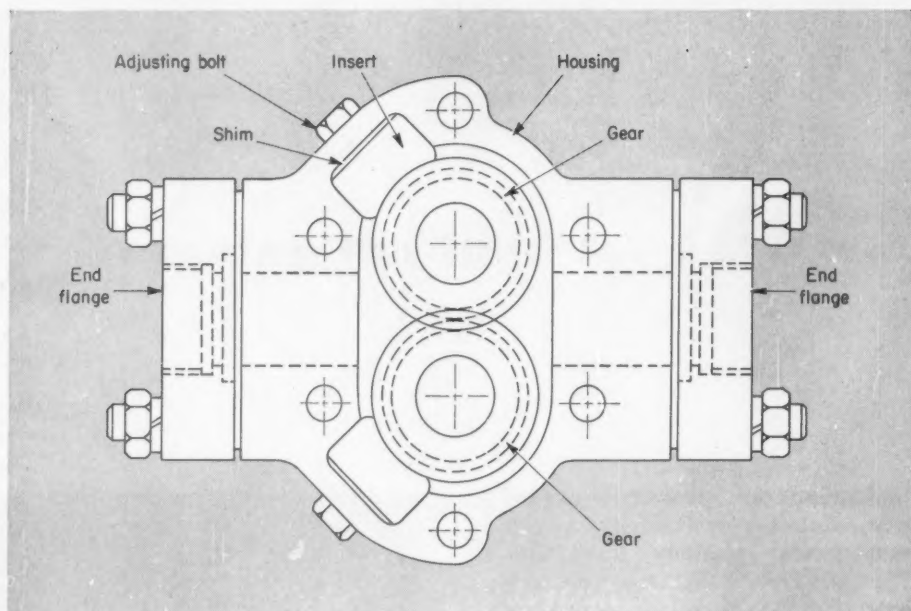
Magnetic clutching provides accurate two-direction stepping for control of rotary position mechanisms. Two rotary solenoid armatures which face one another provide the magnetic force. As the clutch is drawn toward one of the solenoids (depending upon direction of rotation), it engages an armature plate and rotates with the plate as it follows a path in an inclined race of a set of ball bearings. This rotary motion causes shaft rotation. When the solenoid is de-energized the armature plate returns to its original position, but the clutch, armature hub, and shaft are held in the displaced position by a detent. Magnetic clutch principle employed in the Syncramental motor developed by G. H. Leland Inc., Dayton, Ohio.



Instantaneous power reversal

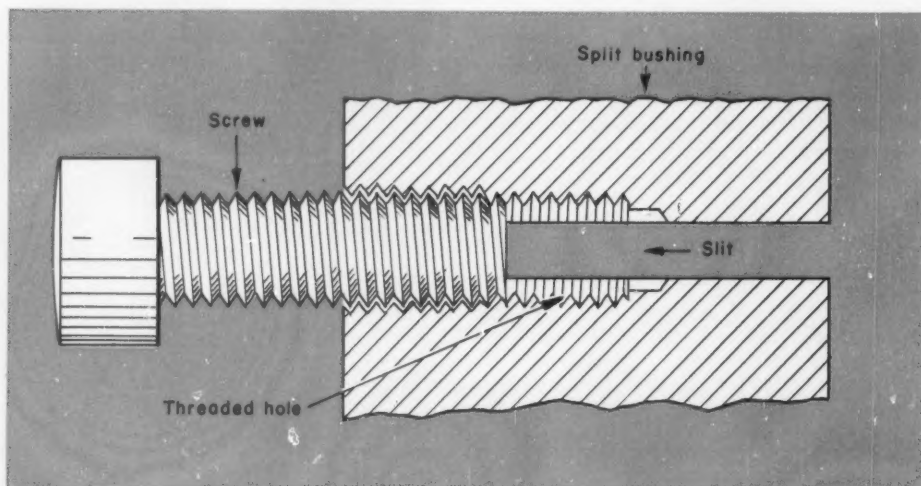
is provided in a small drive unit by a hand-operated planetary transmission. The front half of the drive housing is attached to the ring gear of the planetary and the rear half of the housing is attached to the planet carrier. The input shaft carries the sun or pinion gear. A dog clutch on the output shaft can be shifted back and forth to engage the output shaft with either the ring gear or planet carrier. When the front housing (ring gear) is held firmly by hand and the dog clutch is engaged with the planet carrier, output motion is in the same direction as the input. When the rear housing (planet carrier) is firmly held, and the dog clutch is engaged with the ring gear, output direction is reversed. When the housing is permitted to rotate freely, no power is transmitted. Hand-operated planetary system employed in a push-pull tapper developed by Supreme Products Corp., Chicago, Ill.





Adjustable inserts control gap between gear teeth and casing wall in a gear-type pump. To compensate for the wear which causes back flow between the gears and housing, a controllable gap is provided between the high and low pressure cavities by the inserts. The inserts replace con-

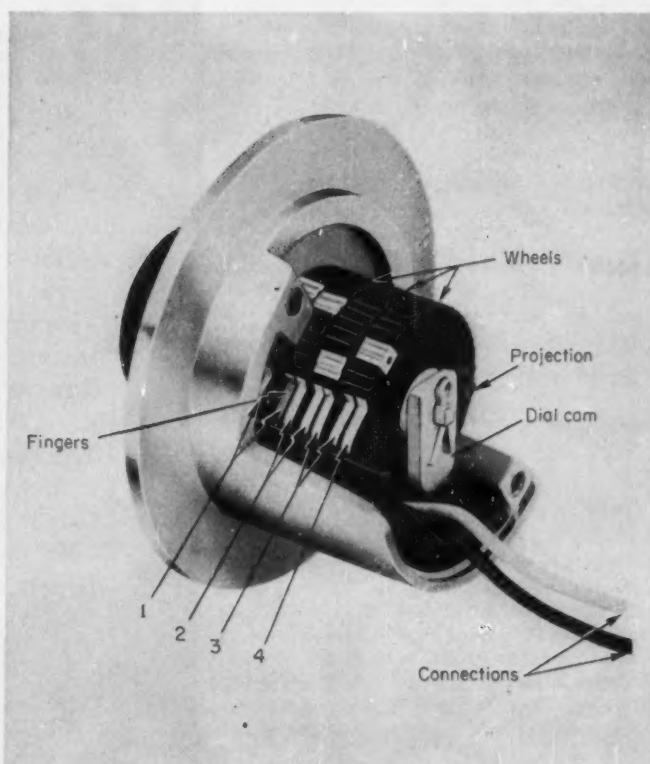
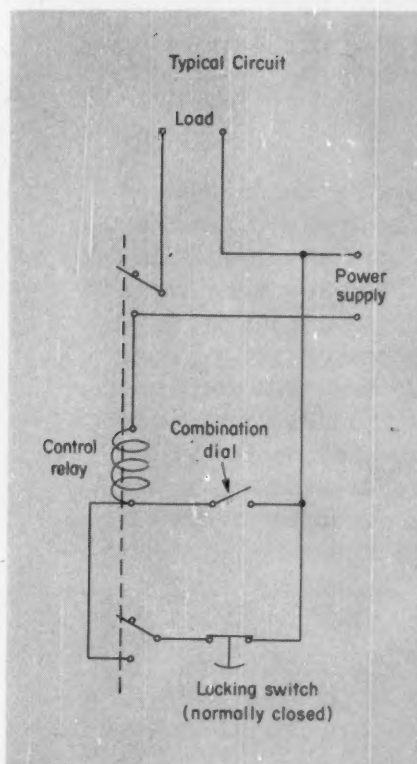
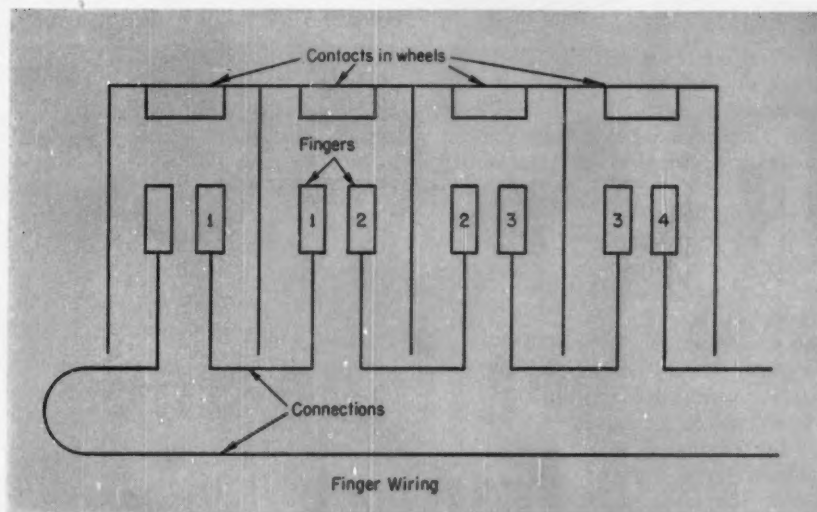
ventional casing liners and are adjusted by bolts. A shim packing is used to give the proper clearance. As the gears and inserts wear, thicker packings are installed. Reported in *Digest of Soviet Technology*, shim principle is employed in a marine gear pump by a Soviet manufacturing concern.

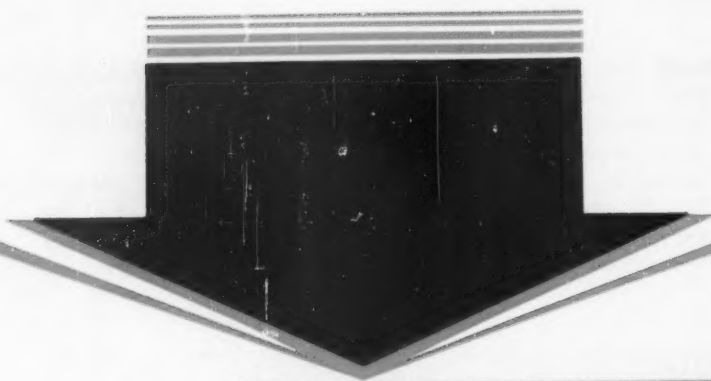


Tapped end-wall simplifies removal of split bushing and hub assemblies from a shaft. A hole is tapped longitudinally along the split in the end of a bushing, to form accurate mated threaded sections in the end walls. When a screw is turned into

the threads, the ends of the bushing are moved away from each other, expanding the bushing and freeing it from the shaft. Tapped split-bushing principle employed in a food pulverizing machine developed by Bloomquist Machine Mfg. Co., Wausau, Wis.

Contact wheels are aligned to "lock" or "unlock" electrical circuit. Each of several plastic wheels contains a metal electric contact point on the circumference. The position of the wheels is determined by a numbered dial, which controls alignment under a set of fingers. The fingers are made in pairs and are connected electrically at the bottom. Each set is insulated from the next set and will pass current only when the wheel contacts rest at the right point. When all of the contact points are lined up, the circuit is closed. Contact principle employed in the Electro Dial developed by Electro Dial Inc., Van Nuys, Calif.





malleable IRON

Fatigue and Impact Effects

When heavily loaded, either suddenly or cyclically, most materials fail at lower stress values than if the loads were static. This article reports the results of recent investigations to show how well malleable-iron castings withstand dynamic loads. The report is condensed from a new handbook, *Malleable Iron Castings*, available early in 1960 from Malleable Founders Society, Cleveland.

IN many applications, malleable-iron castings are subject to dynamic loading. When loads are applied suddenly, the metal's impact resistance determines the survival of castings. When loads are cyclic, either regular or erratic, failure is attributed to fatigue. This article describes the behavior of malleable-iron castings under both kinds of dynamic loading.

► Fatigue Properties

Failures caused by cyclic stresses are generally progressive and devoid of plastic deformation near the fracture. For parts which are highly dynamically loaded in service, fatigue properties may be more important than other properties.

Types of loading methods used in fatigue testing include axial loading in tension or compression, torsional loading, and loading by reverse bending of a flat specimen or a rotating beam. Usually, fatigue life is increased by reducing applied stress. For ferrous materials, the curve for stress versus cycles-to-failure changes slope rapidly between 1 and 10 million cycles so that a small reduction in applied stress results in a very large increase in life. Frequently specimens which endure 10 million cycles are considered "runouts" which would last indefinitely.

Definitions: Fatigue limit, or endurance limit, is the limiting value of the stress below which a material can presumably endure an infinite number of stress cycles; that is, the stress at which the stress-versus-cycles diagram becomes horizontal and appears to remain so.

Fatigue strength is the greatest stress which can be sustained for a given number of stress cycles without fracture.

Table 1—Fatigue Properties of Typical Malleable Irons

Type of Malleable Iron	Tensile Strength (psi)	Fatigue Limit* (psi)	Fatigue Ratio†
High Carbon	45,000	28,000	0.60
	50,000	20,000	0.40
Medium Carbon	53,000	24,000	0.50
	53,000	32,000	0.60
Low Carbon	53,000	26,000	0.50
	54,000	36,000	0.65
	58,000	33,000	0.55

Notes: All values are for unnotched specimens.

*Presumed to be median fatigue limits.

†Values are listed to nearest 0.05.

Fatigue ratio is the ratio of fatigue limit, or fatigue strength, to static tensile strength, Table 1. This value is not constant for various stress levels and for differently designed test specimens, so it must be used with qualifications.

Notch Sensitivity: Fatigue test data are generally obtained with highly-polished specimens in order to reduce scatter. Rough or corroded surfaces can greatly reduce fatigue strength, particularly at high strength and hardness. Any notch, sharp corner, or discontinuity in a part can cause a stress concentration. Castings are seldom polished to the same degree as fatigue test specimens, so some measure of the effect of notches or surface irregularities on fatigue life is important.

Fatigue strength reduction factor, or fatigue notch factor, K_f , is the ratio of the fatigue strength of a member or specimen *without* stress concentration to the fatigue strength *with* stress concentration. The closer K_f approaches unity, the less sensitive the condition is to fatigue failure. Values of K_f vary with material, severity of notch, type of notch, type of loading, and severity of loading. Fatigue notch factor has no significance unless these conditions are stated, Table 2.

Residual Stress: Normally, malleable iron castings are free from residual stress because of the anneal-

Table 2—Effect of Notch Design on Fatigue Notch Factor

Specimen Diam (in.)	Notch Dimensions* Base Radius (in.)	Depth (in.)	Fatigue Strength‡ (psi)	K_f	Fatigue Ratio
0.300	—Unnotched—		26,000	..	0.49
0.505	0.005	0.028	15,500	1.7	0.29
0.505	0.010	0.028	19,750	1.3	0.37
0.505	0.030	0.030	16,000	1.6	0.30

Notes: All values are for grade 32510 malleable iron.

*For 60-deg V-notches.

‡Presumed to be median fatigue strength.

Table 2 Addendum: After values listed had been obtained, the depth of the notch was increased from about 0.03 in. to about 0.08 in. Result: The fatigue strength of specimens with a 0.010-in. radius at the base of a 60-deg notch was essentially unchanged. However, similar changes in the depth of notches in specimens having 0.005-in. and 0.030-in. radii at the base of the notch caused the fatigue strength to fall off to 9500 to 10,000 psi, and the fatigue notch factor, K_f , to increase to 2.6 to 2.7.

malleable IRON

Fatigue and Impact Effects

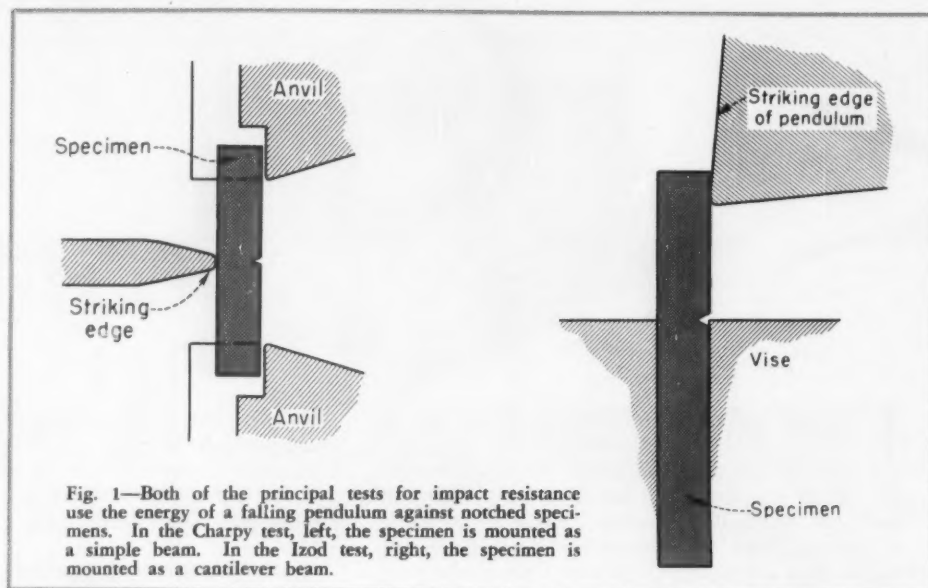


Fig. 1—Both of the principal tests for impact resistance use the energy of a falling pendulum against notched specimens. In the Charpy test, left, the specimen is mounted as a simple beam. In the Izod test, right, the specimen is mounted as a cantilever beam.

ing treatment employed in their manufacture. It is known, however, that in the proper location, residual compressive stresses can improve fatigue life appreciably. Such stresses can be impressed into critical areas by shot blasting, rolling of fillets, tumbling, over-stressing, or coining. In actual tests of cantilever fatigue, the average life of peened specimens was five times that of nonpeened, and the lowest-stressed of eight peened specimens lasted nearly three times as long as the highest of eight nonpeened samples.

Impact Resistance

Impact resistance is the ability of a material to withstand shock. The energy absorbed, or the number of blows of a given intensity necessary to produce fracture, are the values usually expressed. The two principal impact tests are Charpy and Izod, Fig. 1.

Resistance to impact has not been reduced to a single test equally applicable to all metals. For some materials, including iron, notched specimens used in the Izod and Charpy tests give a dependable indication of impact resistance. For some others, which are more influenced by the concentration of stress at the notch, these tests are a truer measure of notch sensitivity than impact resistance. The tests

do show that more failures occur in metals which have very low Izod or Charpy impact values than in those which have high ones. But the notched-bar test does not give accurate enough results on metals of different notch sensitivity.

As measured by the Izod test, with a V-notch, 0.394-in. square bar, and 0.079-in. depth of notch, the impact value of standard malleable iron is about 16.5 ft-lb. Impact tests employing standard Charpy V-notched specimens have given values in the range of 14 to 17 ft-lb at room temperature for commercial heats of standard malleable iron.

Tensile impact resistance is measured with a test bar turned to a diameter of 0.236-in. and a gage length of 2 in. as provided in ASTM specifications. The threaded ends of the bar engage the pendulum of the testing machine and an impact block which strikes an anvil as the pendulum descends. Tests with the machine at 200 ft-lb capacity and at room temperature produced the results in Table 3.

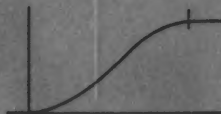
Several other tests measure significant properties. Behavior of ferrous materials in the presence of a sharp notch or crack-starter—generally produced by the use of a brittle weld material on the surface of the specimen—is measured by the drop weight test. The test seeks to ascertain whether the base material is capable of a small amount of deformation in the presence of a sharp notch. If it is not, brittle fracture occurs. The test establishes the critical nil-ductility point at which the specimen breaks completely or remains essentially intact.

The explosion bulge test is used to investigate the relative resistance of a material to the initiation and propagation of fracture at temperatures above the nil-ductility transition temperature. The performance of standard malleable iron in both the drop-weight and the explosion bulge test indicates that it is not susceptible to brittle failure at room temperature.

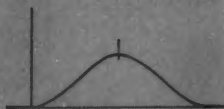
Table 3—Impact Strength of Standard Malleable Iron

Tensile Strength (psi)	Yield Point (psi)	Elongation (per cent in 2 in.)	Tensile Impact Strength (ft-lb)	Impact Elongation (per cent)
54,300	35,400	21	43.5	11
57,200	36,500	14.5	25	8

Dwell-rise-dwell is the most common cam function. Available procedures and tables simplify profile design.



But how do you design for rise and fall with no dwell between?



Or for rise-fall-rise, with differing displacement-time ratios for each event?



Here's how to adapt existing design methods to . . .

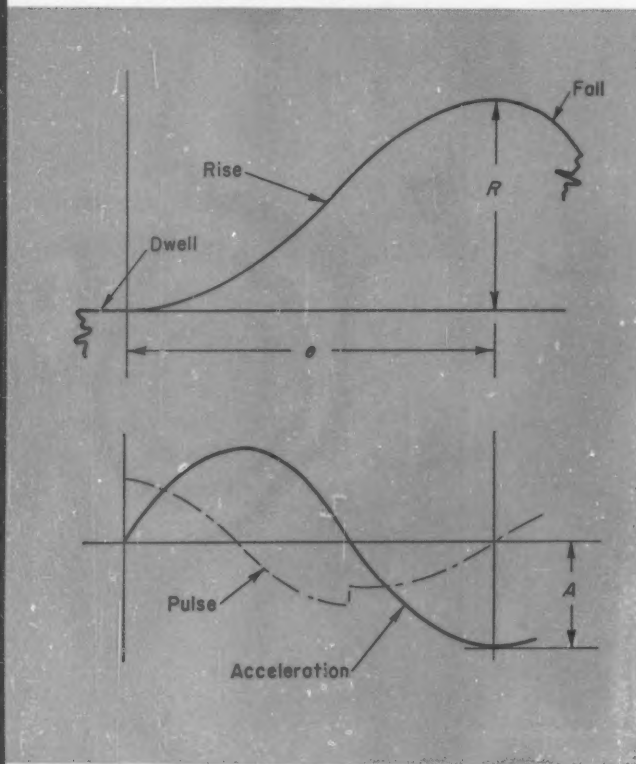
Continuous Cam Curves

DISPLACEMENTS obtained with cams are usually preceded and followed by a dwell. For this type of cam displacement, various curves, such as cycloidal, modified trapezoid, and others, have been developed. The objective of these curves is to limit the acceleration and apply it gradually at the start and end of the displacement. When a rise is immediately followed by a fall, the displacement curves mentioned have accelerations greater than necessary.

The objective of this article is to develop a system for continuous cam curves by combining cycloidal and harmonic displacements so that the ac-

EDGAR SCHMIDT

Mechanical
Development Laboratory
Engineering Department
E. I. du Pont de
Nemours & Co. Inc.
Wilmington, Del.



1 Typical continuous cam displacement. No dwell occurs between rise and fall.

celeration forces are kept to a minimum and have no sudden changes in magnitude.

In general, for this type of continuous displacement, the acceleration should be applied gradually at the start of the rise and have some finite negative value at the point of reversal. This provision produces a continuous acceleration curve during the transition from rise to fall. Another objective is to keep the acceleration to a minimum and not subject it to sudden changes in magnitude. Finally, by use of cycloidal and harmonic curves, displacement tables already available can be used.

The case to be analyzed can be described as consisting of a dwell-rise-fall path in which the acceleration at the top of the rise is specified or can be independently determined. Fig. 1 represents this typical condition. Displacement R , angle θ , and acceleration A at the point of reversal are given. The problem is to determine the curve profile so that it starts with cycloidal motion, and ends with harmonic motion, with the acceleration having no sudden changes in magnitude. The pulse curve, shown as dot-dash, indicates the change in slope of the acceleration. The sudden change in pulse introduced at the point of inflection is less than that existing at the start of a cycloidal displacement. If the latter is acceptable, a pulse of smaller magnitude during the displacement should be of no concern.

General Case: The matching of the cycloidal and harmonic curves can be developed as shown in Fig. 2. The rise of the displacement is equal to R and occurs in θ degrees. In addition, the magnitude of the acceleration at reversal is given as A . The point of tangency for the two curves is the inflection point and occurs at θ_i . At this point, acceleration produced by the two curves must be equal to zero and the slopes of the cycloidal and harmonic curves must be equal. The rise from 0 to θ_i is half of a cycloidal displacement having a total rise of R_c and occurring in θ_c degrees. It follows that θ_c is equal to $2\theta_i$. The remainder of the given displacement, from θ_i to θ , is half of a harmonic displacement having a total rise of R_h and occurring in an angle θ_h which in turn is equal to $2(\theta - \theta_i)$. It is now necessary to determine for what value of θ_i these two curves will be tangent and the corresponding values for R_c and R_h .

From Fig. 2 the following relationships are self-evident:

$$R_h + R_c = 2R \quad (1)$$

$$\theta_i = \frac{\theta_c}{2} \quad (2)$$

$$\frac{\theta_h}{2} = \theta - \theta_i \quad (3)$$

or

$$\theta_h = 2\theta - \theta_c \quad (4)$$

Angle θ is directly proportional to time for a cam rotating at constant velocity. To simplify the derivation, θ and time will be assumed to be numerically equal. This device will permit velocity and acceleration to be expressed in terms of inches and degrees without use of a proportionality factor.

The ratio between the average slope, or velocity, of a displacement and the slope at the point of inflection on the cam curve has been established for the more common cam curves. In the case of the cycloidal, the maximum slope is twice the average, and for a harmonic it is $\pi/2$ times as great. The slope at the inflection point for the two curves can now be written:

$$\text{maximum slope, cycloidal} = \frac{2R_c}{\theta_c}$$

$$\text{maximum slope, harmonic} = \frac{\pi R_h}{2\theta_h}$$

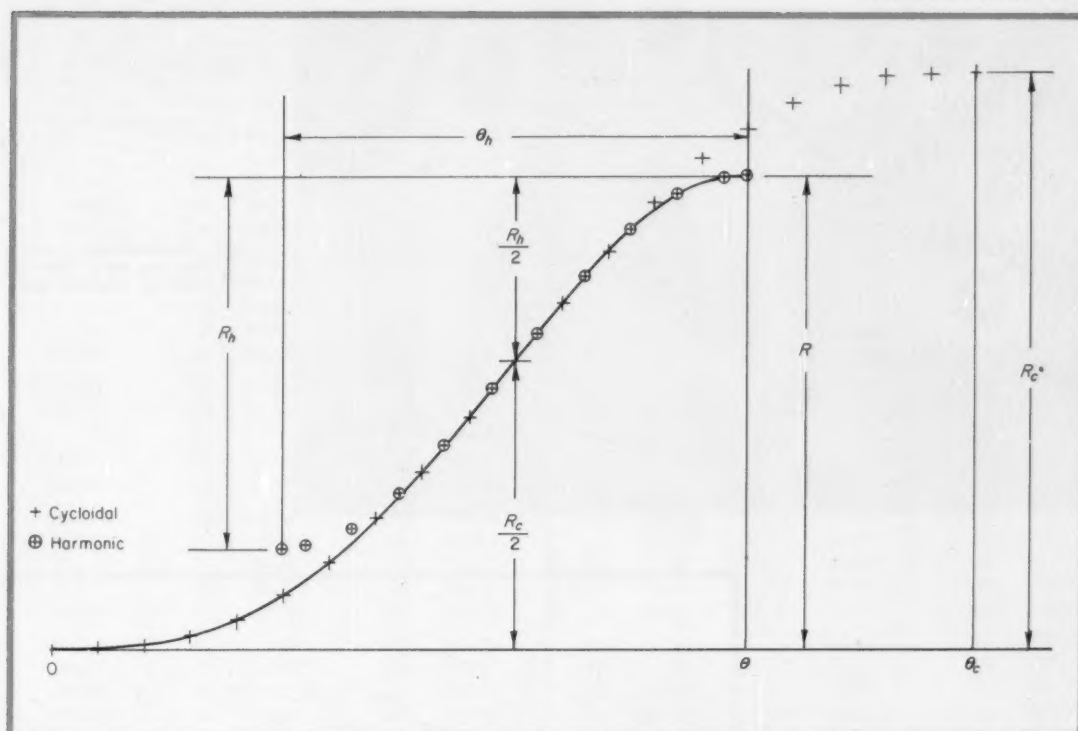
For continuity of the final curve, these slopes must be equal; hence,

$$4R_c\theta_h = \pi R_h\theta_c \quad (5)$$

Substituting the values for R_c and θ_c from Equations 1 and 3 gives

$$8R\theta_h - (4 - \pi)R_h\theta_h - 2\pi R_h\theta = 0 \quad (6)$$

The acceleration at the end of the rise resulting from the harmonic curve can be expressed in terms of R_h and θ_h and should equal the given acceleration A . Hence,



2 Plot showing how cycloidal and harmonic curves are matched.

$$A = A_h = -\frac{\pi^2 R_h}{2 \theta_h^2} \quad (7)$$

or

$$R_h = \frac{2 A \theta_h^2}{\pi^2} \quad (8)$$

Substituting in Equation 6 for R_h and clearing,

$$0.85841 \theta_h^2 + 2 \pi \theta \theta_h - \frac{4 \pi^2 R}{A} = 0 \quad (9)$$

Finally,

$$\theta_h = \frac{-\theta + \sqrt{\theta^2 + 3.43364 \frac{R}{A}}}{0.27342} \quad (10)$$

Although this equation appears rather cumbersome, it can be solved on a slide rule since the value for θ_h actually used should be rounded off to the nearest degree. The acceleration is affected by only a small amount. From θ_h , θ_t , and θ_c can now be obtained from Equations 3 and 2:

$$\theta_t = \theta - \frac{\theta_h}{2} \quad (11)$$

$$\theta_c = 2\theta - \theta_h = 2\theta_t \quad (12)$$

Finally from Equation 8 the rise for the harmonic curve is obtained, and the rise for the cycloidal curve is obtained from Equation 1.

Another expression for R_h can be obtained in terms

of the given rise R and the two angles θ_h and θ_c . Substituting the value for R_c , as given in Equation 1, in Equation 5,

$$R_h = \frac{8 R \theta_h}{4 \theta_h + \pi \theta_c} \quad (13)$$

This general derivation can be applied to a variety of situations involving continuous cam curves. Three cases are investigated here.

Dwell-Rise-Fall-Dwell, Equal Times: Fig. 3 shows the relatively simple case in which rise and fall are equal and occur in the same interval of time. Only rise R and angle θ are given.

It appears to be desirable that the peak cycloidal and harmonic accelerations should be equal. On this basis, the peak acceleration for these two curves can be equated. From Equation 7, the equation for harmonic acceleration is obtained, and the equation for peak cycloidal acceleration can be shown to be:

$$A_c = \frac{2 \pi R_c}{\theta_c^2} \quad (14)$$

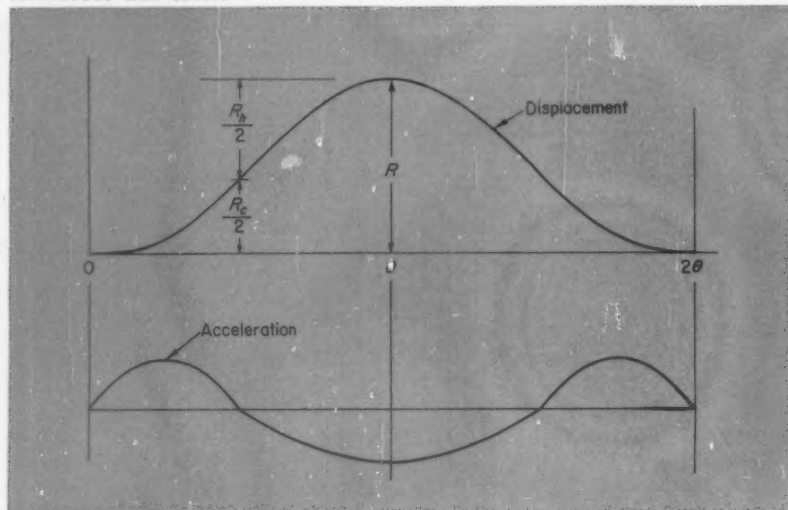
Combining Equations 7 and 14, and clearing,

$$4 R_c \theta_h^2 = \pi R_h \theta_c^2 \quad (15)$$

However, from Equation 5 it is found that $4 R_c \theta_h = \pi R_h \theta_c$. Hence, there is this interesting conclusion:

$$\theta_c = \theta_h \quad (16)$$

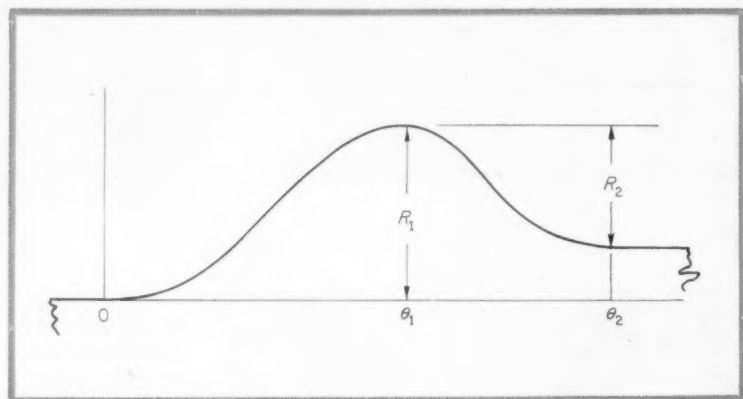
Therefore, it is apparent that, for this type of cam



3 Displacement curve having equal rise and fall in identical times.

Rise and fall with unequal displacement-time ratios.

4



curve, the point of inflection occurs in the center of the cam angle θ , or θ_i is equal to $\theta/2$. When $\theta_o = \theta_h$, Equation 13 becomes

$$R_h = \frac{8R}{4 + \pi} = 1.1202 R \quad (17)$$

And, substituting Equation 17 in Equation 1,

$$R_c = \frac{2\pi R}{4 + \pi} = 0.8798 R \quad (18)$$

To determine the co-ordinates of the cam curve for this case, it is only necessary to solve for R_o and R_h and multiply these by the displacement factors given in the cam tables.

Dwell-Rise-Fall-Dwell, Unequal Times: Fig. 4 depicts the case where the displacement-time ratios for the two displacements are not equal.

It is first necessary to determine which of the two displacements by itself would require the greater acceleration force—that is, which is the more severe of the two. Since acceleration varies directly as the rise, and inversely as the square of the time, the severities of the displacements can be evaluated from the two following equations:

$$S_1 = \frac{R_1}{\theta_1^2} \quad (19)$$

$$S_2 = \frac{R_2}{(\theta_2 - \theta_1)^2} = \frac{R_2}{\theta_2^2} \quad (20)$$

The displacement having the larger value for S should be used to determine its curve by applying Equations 17 and 18 developed for the preceding case so that the peak acceleration and deceleration are equal. This process will produce equal peak accelerations which can be evaluated from Equations 7 or 14. With this value as the acceleration at the point of reversal, R_o and R_h of the other displacement can be obtained by use of the general case.

Dwell-Rise-Fall-Rise-Dwell, Unequal Displacement and Times: Fig. 5 shows this more complicated case. The data usually specified consist of the displacements and cam angles; hence, some method of determining acceleration patterns must be established. Since displacement R_2 is between the other two, it appears logical that it should have some finite acceleration at the beginning and end of its stroke. Under these circumstances, the smoothest

Table 1—Harmonic Displacement						Table 2—Cycloidal Displacement					
x	f	x	f	x	f	x	f	x	f	x	f
1	.000171	41	.261420	81	.761249	1	.000003	41	.208188	81	.816808
2	.000685	42	.273004	82	.772319	2	.000030	42	.221240	82	.828728
3	.001541	43	.284744	83	.783203	3	.000102	43	.234646	83	.840250
4	.002739	44	.296631	84	.793892	4	.000243	44	.248391	84	.851365
5	.004277	45	.308658	85	.804380	5	.000474	45	.262460	85	.862065
6	.006155	46	.320816	86	.814660	6	.000818	46	.276837	86	.872343
7	.008372	47	.333096	87	.824724	7	.001297	47	.291507	87	.882195
8	.010926	48	.345491	88	.834565	8	.001932	48	.306451	88	.891616
9	.013815	49	.357992	89	.844177	9	.002745	49	.321651	89	.900603
10	.017037	50	.370590	90	.853553	10	.003755	50	.337089	90	.909154
11	.020590	51	.383277	91	.862687	11	.004984	51	.352745	91	.917270
12	.024471	52	.396044	92	.871572	12	.006451	52	.368599	92	.924949
13	.028679	53	.408882	93	.880202	13	.008173	53	.384630	93	.932195
14	.033209	54	.421782	94	.888572	14	.010171	54	.400818	94	.939010
15	.038060	55	.434736	95	.896676	15	.012460	55	.417141	95	.945398
16	.043227	56	.447735	96	.904508	16	.015058	56	.433576	96	.951365
17	.048707	57	.460770	97	.912063	17	.017980	57	.450102	97	.956917
18	.054496	58	.473832	98	.919335	18	.021240	58	.466697	98	.962061
19	.060591	59	.486911	99	.926320	19	.024854	59	.483337	99	.966808
20	.066987	60	.500000	100	.933012	20	.028834	60	.500000	100	.971165
21	.073679	61	.513088	101	.939408	21	.033191	61	.516662	101	.975145
22	.080664	62	.526167	102	.945503	22	.037938	62	.533302	102	.978759
23	.087936	63	.539229	103	.951292	23	.043082	63	.549897	103	.982019
24	.095491	64	.552264	104	.956772	24	.048634	64	.566423	104	.984941
25	.103323	65	.565263	105	.961939	25	.054601	65	.582859	105	.987539
26	.111427	66	.578217	106	.966790	26	.060989	66	.599181	106	.989828
27	.119797	67	.591117	107	.971320	27	.067804	67	.615369	107	.991826
28	.128427	68	.603955	108	.975528	28	.075050	68	.631400	108	.993548
29	.137312	69	.616722	109	.979409	29	.082729	69	.647254	109	.995015
30	.146446	70	.629409	110	.982962	30	.090845	70	.662910	110	.996244
31	.155822	71	.642007	111	.986184	31	.099396	71	.678348	111	.997254
32	.165434	72	.654508	112	.989073	32	.108383	72	.693548	112	.998067
33	.175275	73	.666903	113	.991627	33	.117804	73	.708492	113	.998702
34	.185339	74	.679183	114	.993844	34	.127656	74	.723162	114	.999181
35	.195619	75	.691341	115	.995722	35	.137934	75	.737539	115	.999525
36	.206107	76	.703368	116	.997260	36	.148634	76	.751608	116	.999756
37	.216796	77	.715255	117	.998458	37	.159749	77	.765353	117	.999897
38	.227680	78	.726995	118	.999314	38	.171271	78	.778759	118	.999969
39	.238750	79	.738579	119	.999828	39	.183191	79	.791811	119	.999996
40	.250000	80	.750000	120	1.000000	40	.195501	80	.804498	120	1.000000

Table 3—Additive Harmonic-Displacement Factors

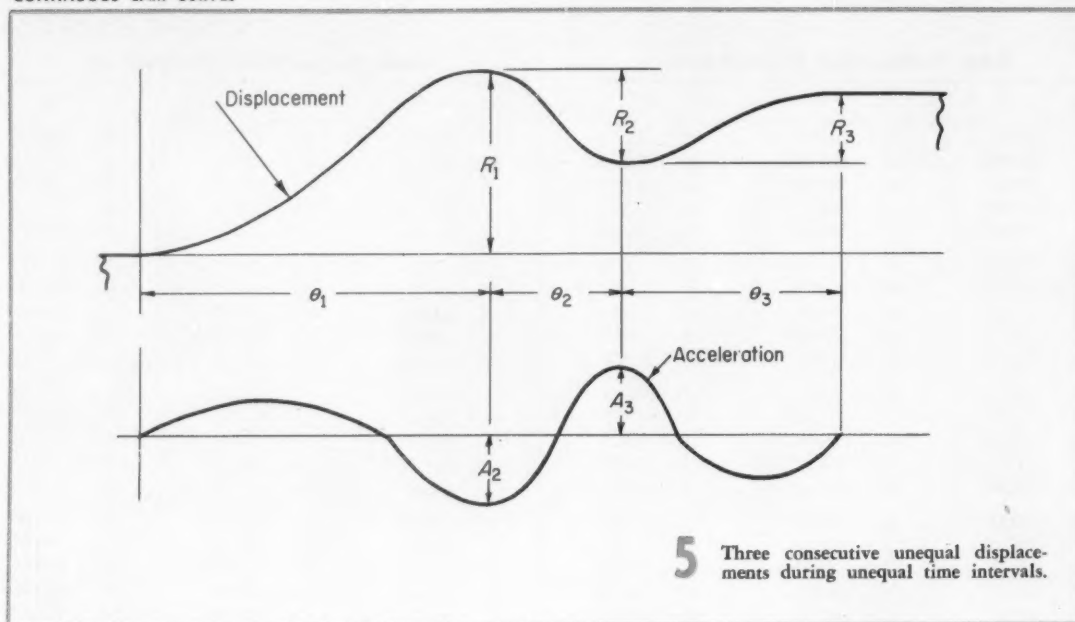
x	a	x	a	x	a	x	a	x	a	x	a
60	.000000										
61	.013088	71	.142007	81	.261249	91	.362687	101	.439408	111	.486184
62	.026167	72	.154508	82	.272319	92	.371572	102	.445503	112	.489073
63	.039229	73	.166903	83	.283203	93	.380202	103	.451292	113	.491627
64	.052264	74	.179183	84	.293892	94	.388572	104	.456772	114	.493844
65	.065263	75	.191341	85	.304380	95	.396676	105	.461939	115	.495722
66	.078217	76	.203368	86	.314660	96	.404508	106	.466790	116	.497260
67	.091117	77	.215255	87	.324724	97	.412063	107	.471320	117	.498458
68	.103955	78	.226995	88	.334565	98	.419335	108	.475528	118	.499314
69	.116722	79	.238579	89	.344177	99	.426320	109	.479409	119	.499828
70	.129409	80	.250000	90	.353553	100	.433012	110	.482962	120	.500000

Note: The harmonic and cycloidal displacement tables conform to the usual conventions of cam tables.

Factor x represents time or travel of the cam. If, for example, an event—a rise or fall between two dwells—is to occupy 120 degrees of cam rotation, x is in degrees. If the event is to occur during 30 deg of cam rotation, each increment of x is $\frac{1}{4}$ deg.

Factor f represents the displacement of the follower. For example, if the total rise is 1 in., f is in inches. If the total rise is 2 in., each value of f should be multiplied by 2.

Factor a offers convenience in the calculation of the harmonic portion of the event. Displacement is equal to the rise to the point of inflection plus the harmonic rise multiplied by factor a .



curve would be a harmonic. Therefore, the value for the terminal acceleration can be determined:

$$A_2 = A_3 = \frac{\pi^2 R_2}{2 \theta_2^2}$$

This value is then used in Equation 10 for the two adjacent rises, R_1 and R_3 .

Example: Determine the cam profiles and acceleration characteristics for a cam, such as shown in Fig. 5, having the following displacements:

$R_1 = 1.0$ -in. rise and angle $\theta_1 = 60$ deg

$R_2 = 0.7$ -in. fall and angle $\theta_2 = 30$ deg

$R_3 = 0.3$ -in. rise and angle $\theta_3 = 40$ deg

Assuming a simple-harmonic motion for the center displacement of 0.7-in. gives the value of A_2 and A_3 :

$$A_2 = A_3 = \frac{\pi^2 (0.7)}{2 (30)^2} = 0.00384 \text{ in. per sec}^2$$

Applying this value for A in Equation 10 permits calculation of the value of θ_h for the 1-in. and 0.3-in. rises. For the 1-in. rise in 60 deg,

$$\theta_h = \frac{-60 + \sqrt{3600 + 3.43364 \frac{1}{0.00384}}}{0.27342} = 25.7 \text{ deg}$$

$$\frac{\theta_h}{2} = 12.85 \text{ deg, say } 13 \text{ deg}$$

Then,

$$\frac{\theta_c}{2} = 47 \text{ deg}$$

The portion of the rise having the harmonic deceleration can be obtained from Equation 13:

$$R_h = \frac{8(1)(26)}{104 + 94\pi} = 0.5208 \text{ in.}$$

$$\frac{R_h}{2} = 0.2604 \text{ in.}$$

$$\frac{R_c}{2} = 0.7396 \text{ in.}$$

Applying the same equations to the 0.3-in. rise in 40 deg, the values are found to be

$$\frac{\theta_h}{2} = 5.6 \text{ deg, say } 6 \text{ deg}$$

$$\frac{\theta_c}{2} = 34 \text{ deg}$$

$$\frac{R_h}{2} = 0.055 \text{ in.}$$

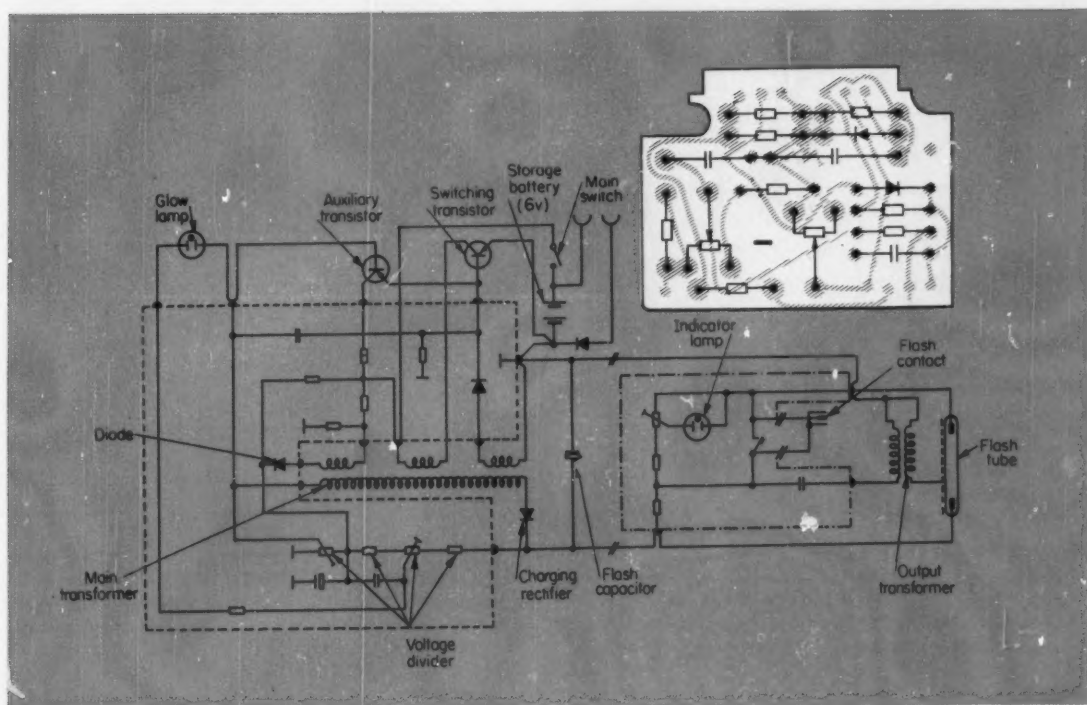
$$\frac{R_c}{2} = 0.245 \text{ in.}$$

The effect of rounding off the point of inflection to the nearest whole number is insignificant. The accelerations resulting from this practice are found to be $A_h = 0.00380$ -in. per sec² for the 1-in. rise and $A_h = 0.00376$ -in. per sec² for the 0.3-in. rise. These are within a few per cent of the matching acceleration of 0.00380-in. per sec².

Tables: Six-place, 120-point tables for harmonic and cycloidal displacements are given in Tables 1 and 2. Table 3 gives additive harmonic displacement factors from the point of inflection. These can be used to obtain continuous values for the displacement during the harmonic deceleration.

The tables, as well as the techniques outlined, are applicable to other cam-design problems. They can be used to design other event cycles or for such chores as adjusting profiles for more equitable acceleration and deceleration.

Controlled Leak Stops Battery Drain In Electronic Flash Circuit

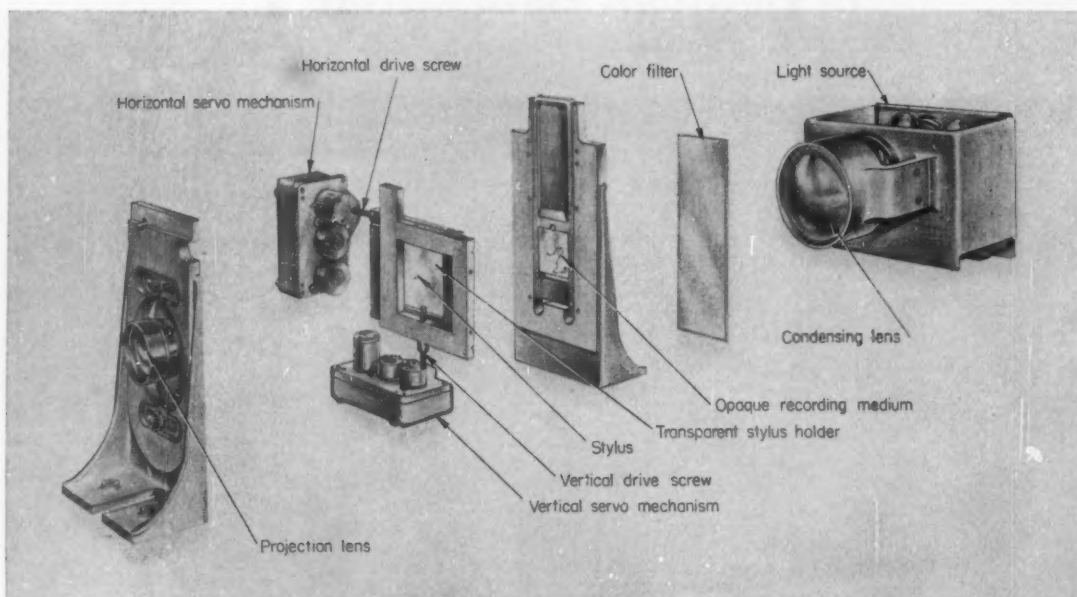


A GLOW LAMP IS USED to direct excess voltage to the base of an auxiliary transistor in a unique capacitor flash unit. Current pulse caused by glow lamp lighting blocks the transistor and suppresses transformer oscillation. The transistor remains blocked until excess voltage leaks away; then transformer oscillation is resumed to maintain the charge on the flash capacitor. Voltage in excess of capacitor needs is transferred to the glow-lamp circuit by a voltage divider. Small auxiliary capacitors store a charge to ignite the glow lamp.

COMPACT FLASHGUN contains the complete unit including battery, printed circuit, transformer, and flash tube. Meca-blitz 103 was designed by Metz Apparatefabrik, Fuerth Bay, Germany.

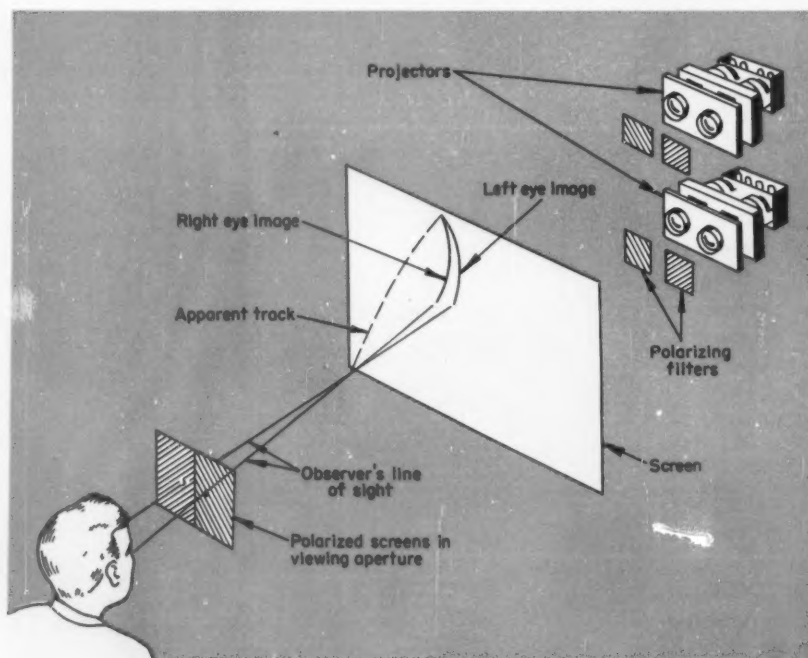


3-D Plotter Uses Transparent Stylus



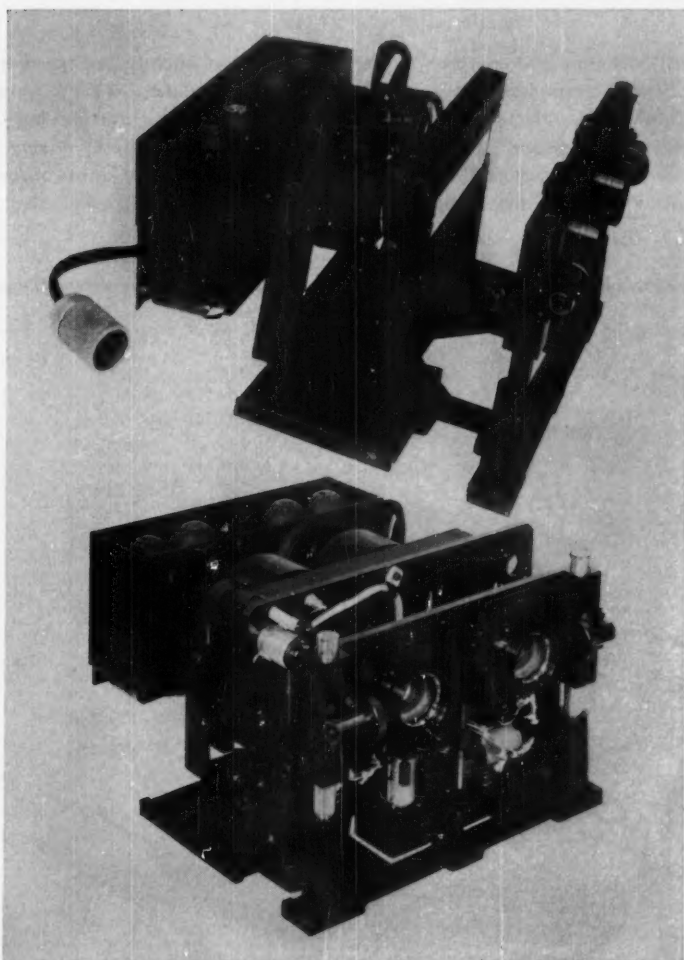
PLOTTING PROJECTOR eliminates obscuring mechanisms by mounting a transparent stylus on a clear sheet. X and Y inputs are fed to horizontal and vertical servo-mechanisms which move the stylus through drive screws. A stereo projector has two of these units. Z input is

fed to the horizontal servomechanisms of the two units, but in opposed sense, so a change of Z component in one direction causes styli to move away from each other—in the opposite direction, to move toward each other.



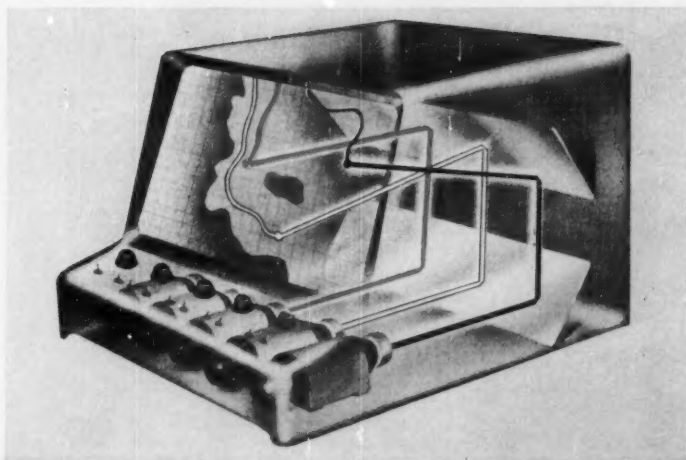
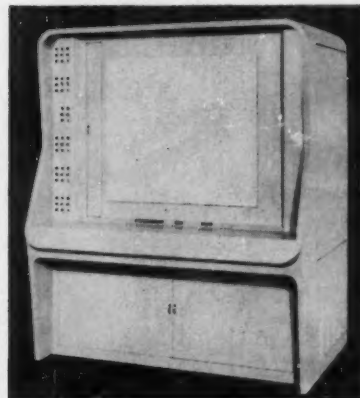
PROJECTED POLARIZED PLOTS present information in depth when viewed through properly oriented polarized screens or spectacles.

To Avoid Obscuring the Plot



THREE-DIMENSIONAL reference grid or other static information is projected by a stereo projector, left, that has color filters, and polarized light filters, but lacks the plotting servo-mechanisms and stylus included in the plotting camera, left below.

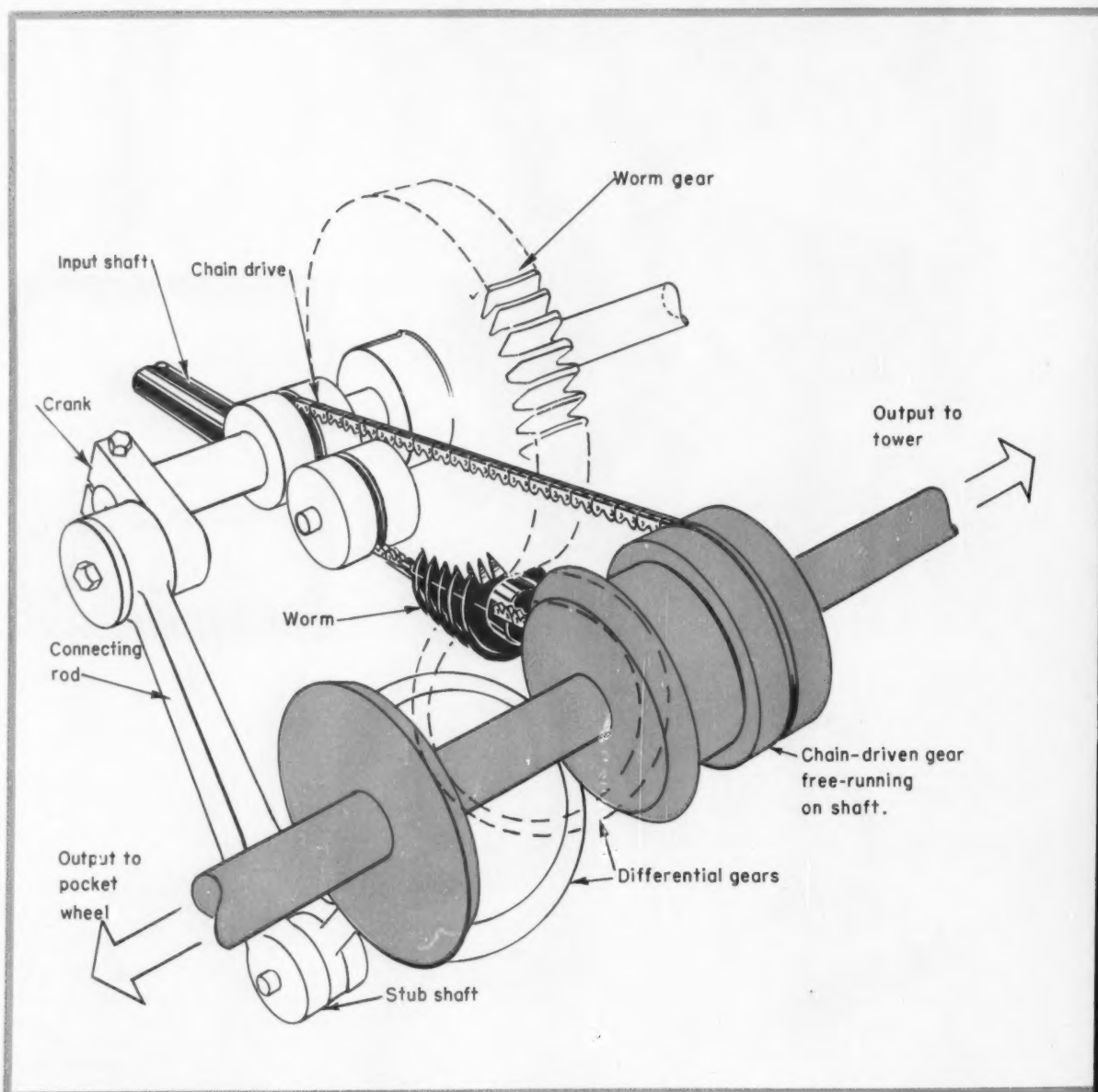
Three-dimensional plotter is made by Fenske, Fredrick, and Miller Inc., Los Angeles. The Iconorama is designed for accuracy within 0.1 per cent along the X and Y axis, and 0.5 per cent along the Z axis.



MULTICHANNEL PLOTTERS use two or more projectors to plot various curves simultaneously without interference. Projectors are corrected for off-axis position, and color filters help distinguish individual plots.

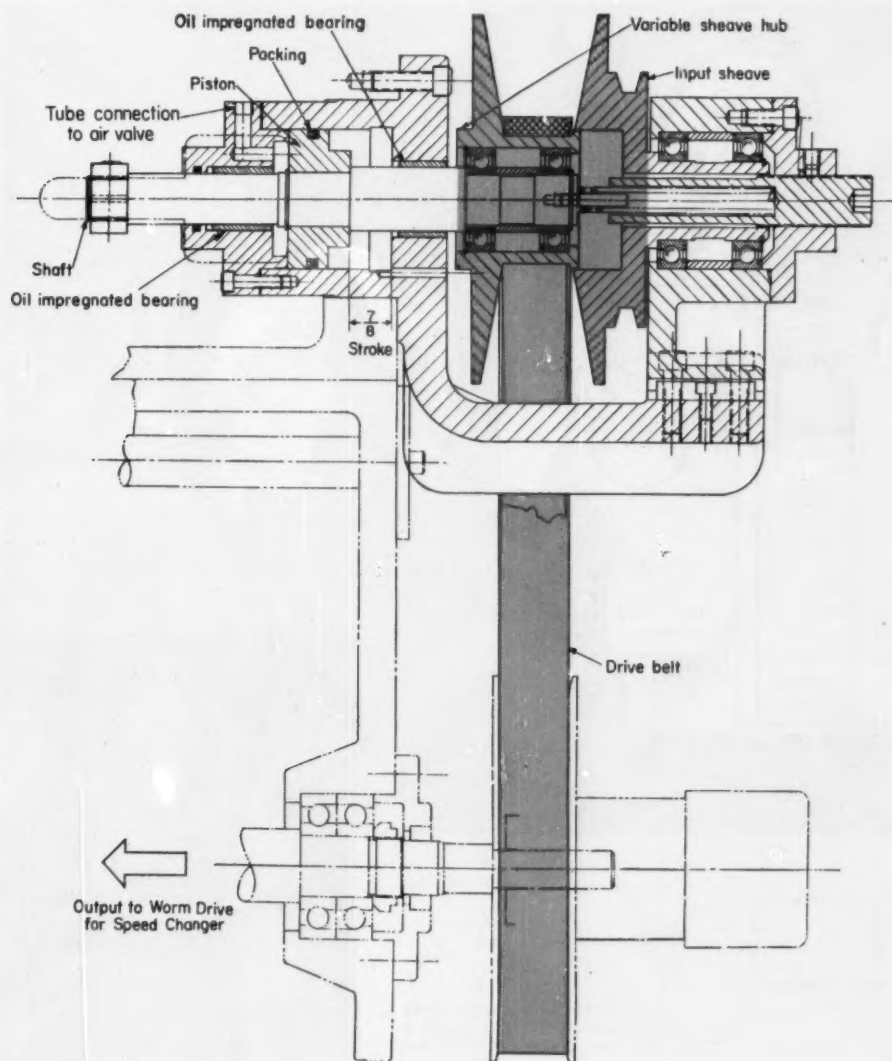
Rocking Differential Provides

SMOOTH TRANSITION from full speed to momentary dwell and back to full speed is produced by a unique differential transmission in a new bottle bander. A crank on a parallel shaft revolves the differential gears part way around the output axis and back, twice during each full rotation of the output shaft. When stub shaft velocity is maximum in one direction, input velocity is cancelled, causing the momentary dwell of the output shaft. Peak motion in the opposite direction doubles speed of the output shaft.



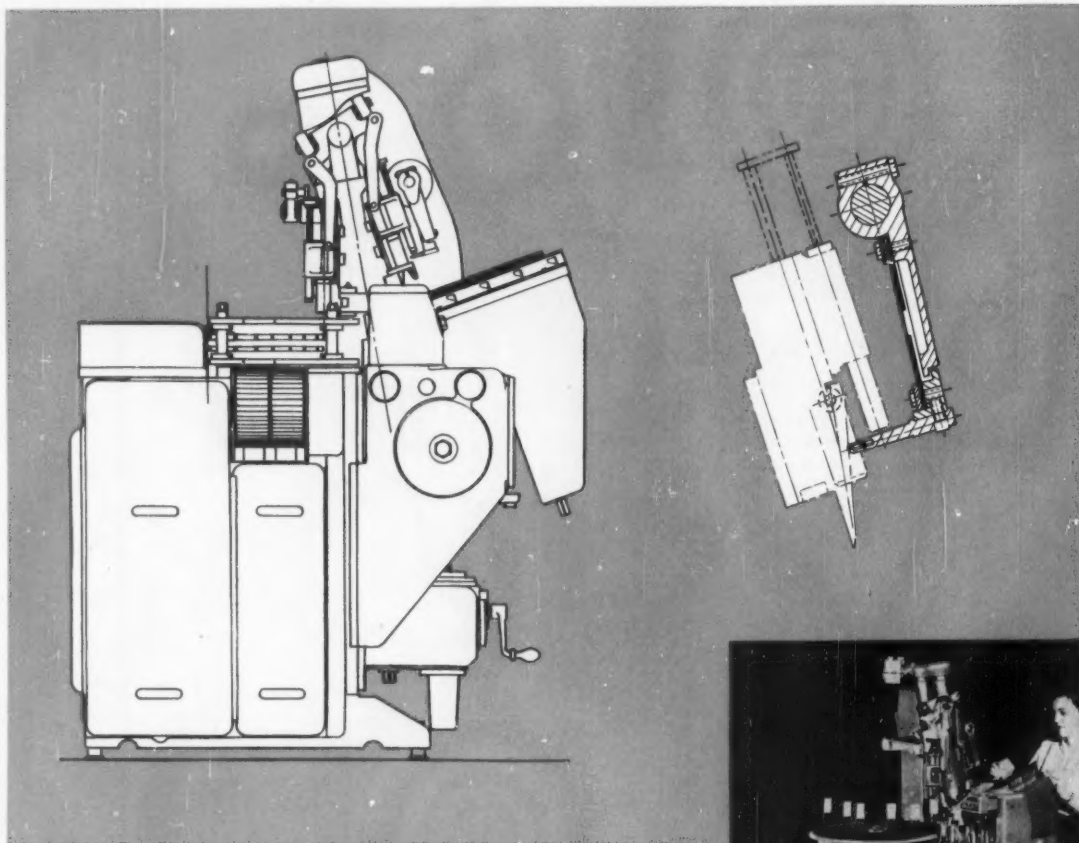
Momentary Dwell for Banding Cycle

PNEUMATIC CLUTCH is actuated by a "message" from wire fingers that sense the presence of a bottle coming through the delivery line. Air pressure forces the variable-sheave hub toward the input sheave, forcing the drive belt up into the vee of the split drive sheave. Speed of drive can be adjusted by varying the stroke of the pneumatic cylinder.

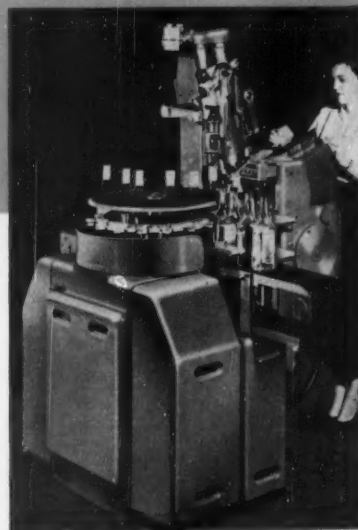


Rocking Differential Provides Momentary Dwell for Banding Cycle

OPERATION OF MANDRELS is cam-controlled. One mandrel is applying a band as the other picks up a new one from the magazine. Bands are precut flattened tubes stacked in a rack. A spearing mechanism with collapsed finger is thrust by cam action into the band to be picked up. The finger snaps open to spread the band; and the mandrel slides into it. In position over the bottle, the band is slid from the mandrel to the bottle neck by a cam-operated stripper. Moistened bands slide on smoothly, but shrink when dry to seal the bottle.



Bottle bander, called Sealomatic "85," is a product of the Gisholt Machine Co., Madison, Wis. Gisholt engineer W. E. Erickson developed the variable-speed differential and other unique features of this machine.



A new design concept
for controlling
control-systems:

Self-Optimizing Servo Circuits

J. M. NIGHTINGALE
Manchester, England

FEEDBACK control systems in general have one basic function: To reduce the error between input and output signals to an acceptable level. Therefore, negative feedback must usually be built into the system, Fig. 1. However, since negative feedback introduces stability problems, a compromise must be reached between the accuracy and stability characteristics designed into closed-loop feedback circuits.

► Idealized Performance Indexes

A number of techniques for designing closed-loop circuits are based on the response of the system to certain idealized input signals. A balanced design is one which has suitable rise time, stability margins, and steady-state errors. However, such a system will not always respond in a satisfactory way, since idealized inputs, such as the step and ramp functions, do not adequately describe a very wide range of input signals.

Performance indexes have been formulated to extend the usefulness of design techniques to include a wide range of possible input signals. These indexes are based on some average property of the error. The performance index most frequently chosen is the average value of the square of error: (see Nomenclature)

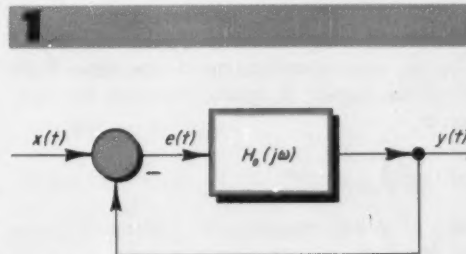
$$E = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T e^2(t) dt \quad (1)$$

The square of error is chosen because it gives an essentially positive index. Its magnitude generally increases as the persistence of large errors increases. The value of E from Equation 1 depends on the parameters of the system.

For example, if loop gain λ is too small, a sluggish

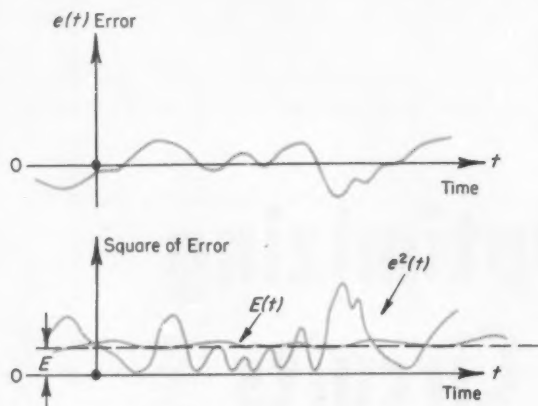
Nomenclature

- E = Mean square of error
- $E(t)$ = Measured mean-square of error
- $e(t)$ = Control-system error
- F = Gain of filter at frequency Ω
- $f(t)$ = Weighting function of smoothing filter
- G = Gain of parameter loop
- $H_o(j\omega)$ = Loop harmonic-response function of control system
- T = Time interval
- t = Time variable
- $\delta\lambda(t)$ = Parameter perturbation
- W_o = Constrained value of $W(t)$
- $W(t)$ = Measure of peak rectified $w(t)$
- $w(t)$ = System variable
- $x(t)$ = Control-system input
- $y(t)$ = Control-system output
- λ = System parameter
- $\Phi_x(\omega)$ = Spectral density function of $x(t)$
- $\phi_x(\tau)$ = Correlation function of $x(t)$
- ω = Frequency variable



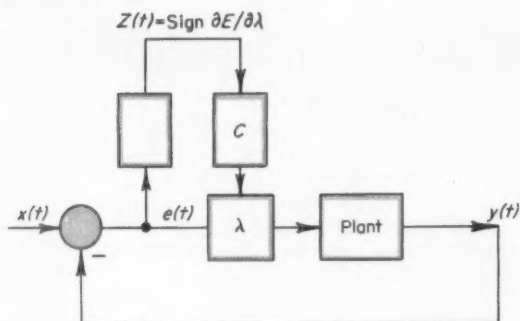
Block diagram depicts a closed-loop control system. Output $y(t)$ is subtracted from input $x(t)$ to give error $e(t)$. The controller and plant are represented by the loop harmonic-response function, $H_o(j\omega)$.

2



Performance index is based on mean-square error E . In practice, only an approximation, $E(t)$, to the mean-square error can be obtained, which fluctuates about the true value of E .

4



Signal $z(t)$ is used to monitor λ through an appropriate control device, C .

response causes large errors. If, on the other hand, λ is too large, the system may approach instability, and the errors become large. Somewhere between these two extremes, there is a value of λ for which E will have its smallest value. This point is specified as the optimum setting of the parameter, λ .

► Practical Parameters

In practice, a computation or measurement of E must be an approximation based on some finite sample of the signal. A typical equation for computation is

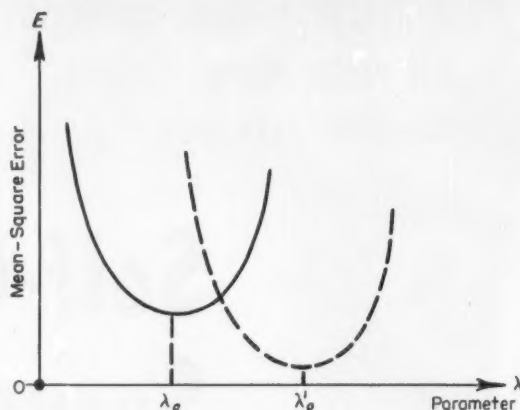
$$E(t) = \frac{1}{T} \int_{t-T}^t e^2(\tau) d\tau \quad (2)$$

Likewise, a typical equation for continuous measurement is

$$E(t) = \int_{-\infty}^{\infty} e^2(\tau) f(t - \tau) d\tau \quad (3)$$

In Equation 2 the interval T must be large, while

3



Curve shows mean-square error variations with changes in control-system parameter λ . Generally, there is a value of λ_o for which E becomes minimum. If the signal or plant characteristics change, a new curve is obtained, for which optimum value occurs at λ'_o .

in Equation 3, $f(t)$ must be the weighting function of a low-pass smoothing filter which has a bandwidth that is considerably less than that of the control system. In these cases, the approximations obtained will be very close to the desired value of E , except for a transient fluctuation, Fig. 2.

As previously stated, $E(t)$ is often independent of time t , and very close to the defined value of E . This is true if the characteristics of the input signal do not change with time. Time-independent inputs can result from a number of casual or random causes, such as the spurious noise voltages encountered in many electrical systems. These signals can best be described statistically, but it is not proposed to discuss details here. However, any signal such as input $x(t)$, can be characterized by

$$\phi_x(\tau) = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T x(t)x(t + \tau) dt \quad (4)$$

In practice, it is necessary to compute or measure this function by using a finite sample of the signal. Then, the mean-square error is

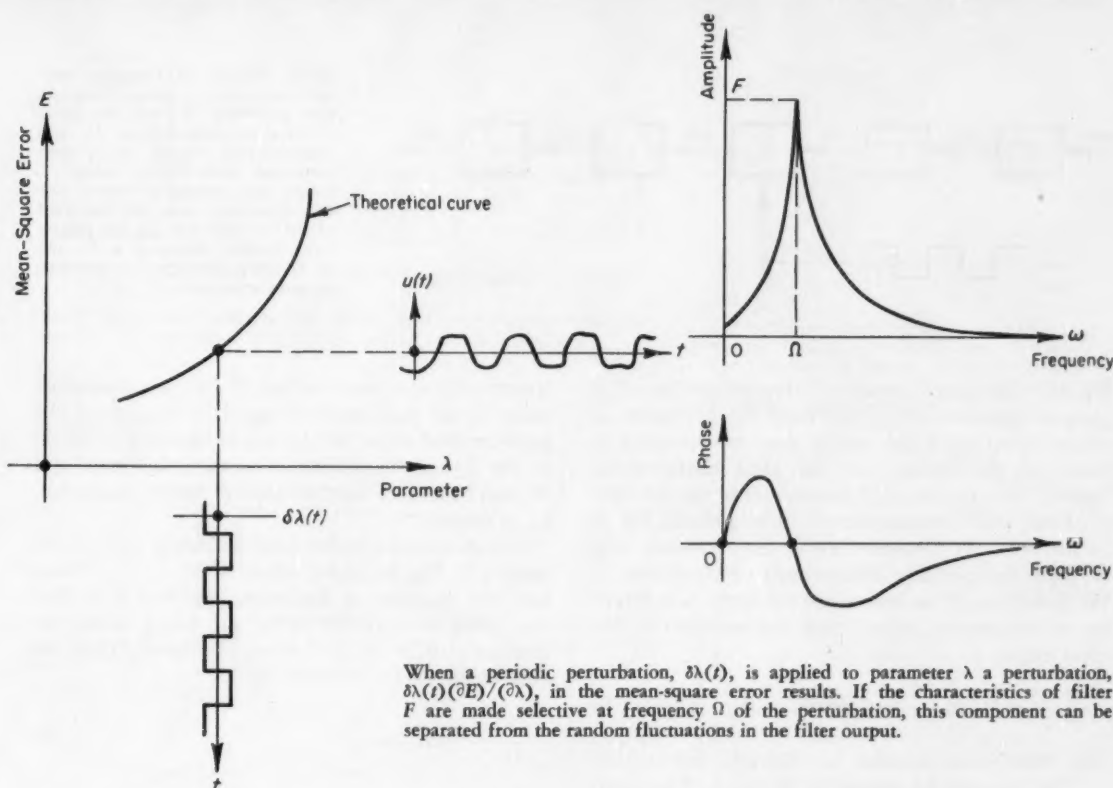
$$E = \frac{1}{2\pi} \int_{-\infty}^{\infty} \frac{\Phi_x(\omega) d\omega}{|1 + H_o(j\omega)|^2} \quad (5)$$

where $H_o(j\omega)$ = loop harmonic-response function,¹ and $\Phi_x(\omega)$ = Fourier transform of $\phi_x(\tau)$. The relation between $\phi_x(\tau)$ and $\Phi_x(\omega)$, called the spectral density function, is given by

$$\Phi_x(\omega) = \int_{-\infty}^{\infty} \phi_x(\tau) e^{-j\omega\tau} d\tau \quad (6)$$

These terms characterize not only a particular signal but a general class of signals which may be different in form but which produce the same value of E

¹References are tabulated at end of article.



When a periodic perturbation, $\delta\lambda(t)$, is applied to parameter λ a perturbation, $\delta\lambda(t)(\partial E/\partial\lambda)$, in the mean-square error results. If the characteristics of filter F are made selective at frequency Ω of the perturbation, this component can be separated from the random fluctuations in the filter output.

in a given system. In many cases, the spectral density function can be approximated by a rational function of ω^2 . For example,

$$\Phi_x(\omega) = \frac{X^2}{\omega^2(\omega^2 + \omega_0^2)} \quad (7)$$

where $X =$ a constant. In such cases, the value of E for a linear system can be computed from tables.² Therefore, E can be obtained as a function of the system parameters, and the optimum value of any parameter λ can be found from

$$\frac{\partial E}{\partial \lambda} = 0 \quad (8)$$

In practice, the computational work involved may be very lengthy, and systems designed in this manner are reliable only if the input signal and plant characteristics do not change.

► Automatic Parameter Control

A number of attempts are being made to produce systems which automatically set the optimum λ , and which can change the setting to maintain optimum conditions if the signal or process characteristics change, Fig. 3. This article describes one type of self-optimizing system for which some success has been achieved.

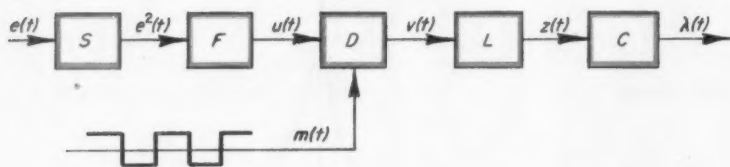
The quantity $\partial E/\partial\lambda$, from Equation 8, changes sign as it passes through the optimum value, λ_0 .

Hence, if a signal, $z(t)$, which is proportional to the sign of $\partial E/\partial\lambda$, can be obtained, it can be used to monitor the parameter through some suitable control device, Fig. 4. To make the parameter loop, an approximate measure, $E(t)$, of the mean-square error is obtained from a smoothing filter, Equation 3. If the response time of this filter is not too great, then the effect of any change in signal or system characteristics on the error can rapidly be seen. However, the filter-response time cannot be too short, or there will be considerable fluctuation in the measured value of $E(t)$.

If a small periodic perturbation, $\delta\lambda(t)$, is applied to λ , then the output of the smoothing filter will contain a component which is roughly proportional to $\delta\lambda(t)(\partial E/\partial\lambda)$. If the filter is made very selective at the perturbation frequency, Ω , Fig. 5, this component can be made to dominate the output of the filter. Hence,

$$u(t) \approx F \frac{\partial E}{\partial \lambda} \delta\lambda(t) \quad (9)$$

Thus, the phase of the filter output, relative to the applied perturbation, depends on $\partial E/\partial\lambda$. Hence, it also depends on which side of the optimum setting that λ occurs. If $u(t)$ is passed through a phase-sensitive detector, signal $v(t)$ is obtained, and $v(t)$ is roughly proportional to the sign of $\partial E/\partial\lambda$. Hence, the signal $v(t)$ can be used to adjust λ . The complete parameter loop is shown in



Block diagram of complete self-optimizing loop consists of square-law generator S , selective filter F , product demodulator D , and demodulating signal $m(t)$, synchronized with $\delta\lambda(t)$. Limiter L makes the parameter control signal dependent only on the sign of $\partial E/\partial\lambda$ and not on its magnitude. Control device C is for use to adjust λ through, for example, an integrating motor.

Fig. 6. The phase-sensitive detector consists of a product demodulator D followed by a limiter L , where signal $m(t)$ is a square wave synchronized to $\delta\lambda(t)$. If the limiter has the ideal characteristic shown, then output $z(t)$ depends only on the sign of $\partial E/\partial\lambda$, and is independent of its magnitude, Fig. 7. In this way, the response time of the parameter loop is made substantially independent of conditions in the main loop. If parameter control device C is driven by an integrating motor, then the equation of the ideal loop is

$$\frac{d\lambda}{dt} = -G \text{sign} \frac{\partial E}{\partial \lambda} = G \text{sign} (\lambda_0 - \lambda) \quad (10)$$

The steady-state solution for this equation is $\lambda = \lambda_0$. The theoretical response for Equation 10 is shown in Fig. 8.

The ideal equation does not exactly describe the system behavior, because:

1. There are random fluctuations in the loop due to incomplete smoothing of the square of error.
2. There are time lags, backlash, and other nonlinear effects in the parameter-control device.
3. The dynamic effects of the tuned filter, which must be heavily damped when the loop is closed, tend to produce oscillations at frequency Ω .

To insure stability in the parameter loop, and to keep random errors in λ small, a small linear zone is provided in the limiter characteristic, Fig. 7. The scalar gain of the parameter loop in the linear zone must be chosen to give a compromise between the magnitude of random error and the speed of response, since both of these factors increase with increases in G .

► Applications

This technique seems to be particularly applicable when there is an additional constraint on one of the control-system variables, for example, on the peak value of output velocity or acceleration.³ These are limitations which might be imposed to safeguard the servomotor. Therefore, it is required to maintain the relationship

$$\lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T |w(t)| dt = W_0 \quad (11)$$

where $w(t)$ = a variable, and W_0 = the constrained value of the peak-rectified signal. A measure of the peak-rectified signal, $W(t)$, can be obtained as shown in Fig. 9, and the difference between this value and W_0 can be used to monitor another system parameter, λ_2 , as shown.

Use of this constraint loop defines a curve of λ_2 against λ_1 , Fig. 10, along which $W(t) = W_0$. Therefore, the function of the optimizing loop is to find the value of λ_1 , and hence λ_2 , which gives the minimum value of $E(t)$ along this curve. Thus the ideal equations for the loops are

$$\frac{d\lambda_1}{dt} = -G_1 \text{sign} \frac{\partial E}{\partial \lambda} \quad (12)$$

and

$$\frac{d\lambda_2}{dt} = G_2(W_0 - W) \quad (13)$$

where $\delta\lambda$ is an element of length along the curve of constant $W(t)$. These equations should have a steady-state solution at the optimum point Λ_1, Λ_2 .

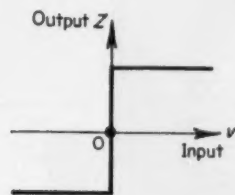
An applied perturbation, $\delta\lambda_1(t)$, induces a perturbation in the constraint loop, $\delta\lambda_2(t)$, such that,

$$\delta\lambda_2(t) = - \left\{ \frac{\frac{\partial W}{\partial \lambda_1}}{\frac{\partial W}{\partial \lambda_2}} \right\} \delta\lambda_1(t) \quad (14)$$

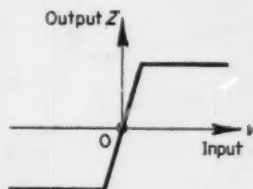
This relation holds true only if the constraint loop can respond to perturbations at frequency Ω . If Equation 14 is satisfied, the output of the detector in the optimizing loop will depend on $\partial E/\partial\lambda$, rather than $\partial E/\partial\lambda_1$.

Where two or more parameter loops are used together, there is a problem of interaction between the loops. These complications add to the problems of stability and accuracy in the individual loops. Generally, this means that the loops must be less sensitive than they could normally be if used individually.

In a sense, the self-optimizing system is continuously performing a statistical experiment. That is, a parameter is varied slightly, the resulting changes are averaged, and a decision is made which depends on the resulting trend. Here, the decision is the

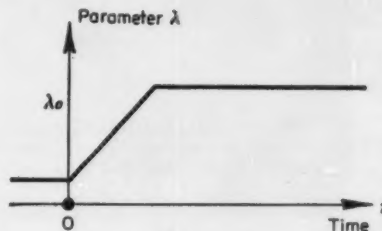


Ideal Limiter Characteristic

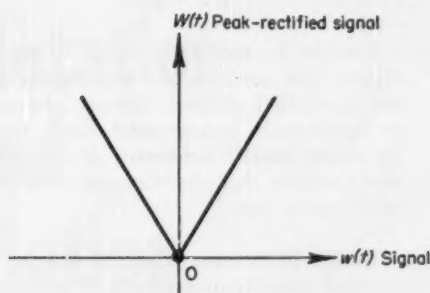
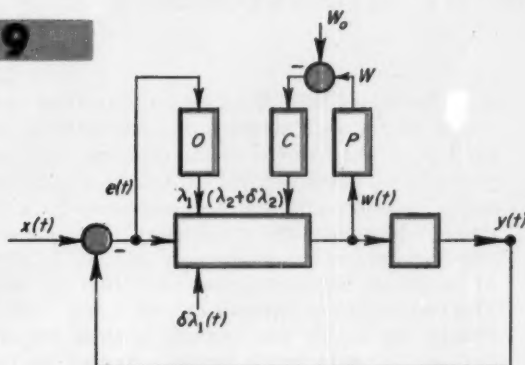


Modified Limiter Characteristic

Small linear zone must be introduced in limiter characteristics to stabilize the parameter loop and to reduce random fluctuations.



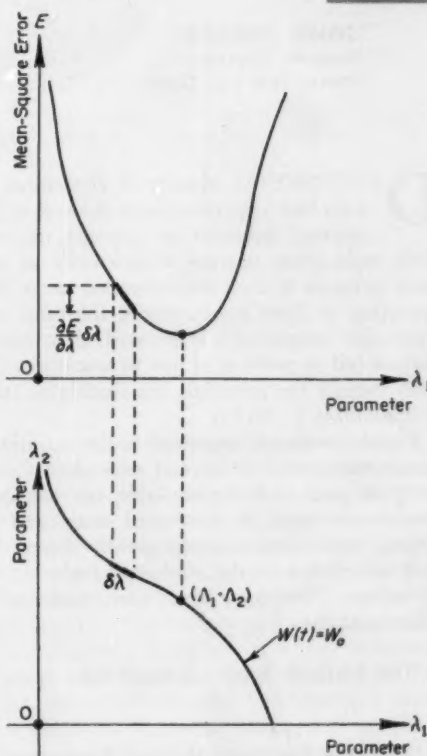
Curve shows idealized response when system is initially displaced from optimum. The response, in theory, results in a steady-state condition $\lambda = \lambda_0$. In practice, there is a random variation about λ_0 .



Rectifier Characteristics

A self-optimizing loop O can be used with a second loop which constrains the peak-rectified value of one of the control-system variables to the value W_0 . This constraint loop adjusts parameter λ_2 through control device C .

Condition $W(t) = W_0$ defines a curve of λ_2 against λ_1 . The value of E will have a minimum value at some point (λ_1, λ_2) along the curve. If the sign of $\partial E / \partial \lambda$ is measured approximately, the self-optimizing system monitors the parameters to the optimum values.



simple one of either increasing or decreasing the parameter.

In laboratory experiments, these loops have been made to perform quite satisfactorily. However, the applications for which this technique is most useful have not been fully investigated to date. Before the extra complication of any self-optimizing system is applied, the designer should be sure that sufficient

improvement in system performance will be achieved.

REFERENCES

1. J. M. Nightingale—*Hydraulic Servo Fundamentals*, Vol. 1, 2, and 3, (reprinted from *MACHINE DESIGN*), Penton Publishing Co., Cleveland, Ohio, 1956 and 1957.
2. J. H. Laning Jr. and R. H. Battin—*Random Processes in Automatic Control*, McGraw-Hill Book Co., New York, N. Y., 1956.
3. G. C. Newton Jr., L. A. Gould and J. F. Kaiser—*Analytical Design of Linear Feedback Systems*, John Wiley & Sons Inc., New York, N. Y., 1957.

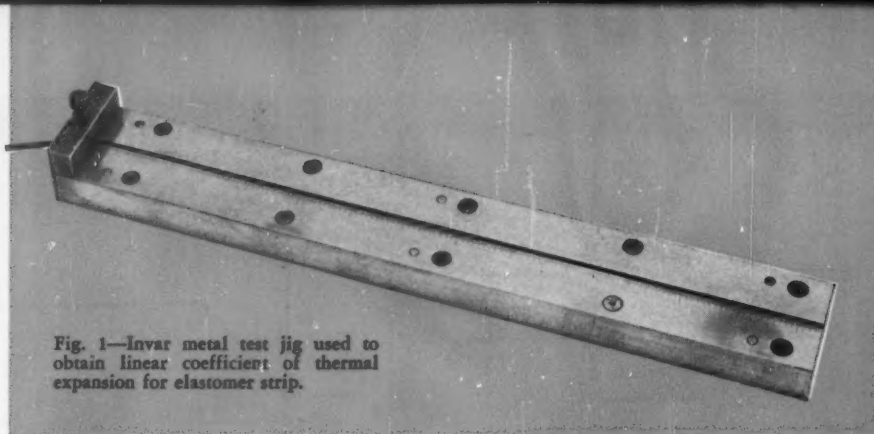


Fig. 1—Invar metal test jig used to obtain linear coefficient of thermal expansion for elastomer strip.

Thermal Expansion of Elastomers

Like every other material, synthetic rubber swells and shrinks with changes in temperature. Tests give new design data for seals.

JOHN JORDAN

Research Engineer
Parker Seal Co., Culver City, Calif.

DIMENSIONAL change of elastomers used in seals has been considered the reason for their unusual behavior at extreme temperatures. Such seals often operate satisfactorily at temperatures in excess of their recommended range. But after operating at these temperatures, the same seals fail when the temperature is lowered. Also certain seal designs fail to perform at low temperatures (-40°F) even though the materials are flexible at still lower temperatures (-65°F).

Development of improved seals requires precise linear coefficients of thermal expansion. Coefficients for pure gum stock are available, but not for typical compounds used in reinforced seals and gaskets. Often, coefficients reported greatly exceed the normal value, due to the confusing inclusion of mold shrinkage. Therefore, tests were made to provide additional data.

Test Method: A jig was made from Invar because

of its low coefficient. A key-way of the same cross section as the seal material was machined in the jig, Fig. 1. The free end of the elastomer strip was placed in the keyway opposite the 12 in. mark of the scale. The other end was held stationary by a pin through both the strip and keyway. The assembly was then placed in a chamber at -40°F . After 24 hr, length of the strip was read from the scale. This procedure was repeated at -65°F and -100°F . Finally, the test jig was returned to room temperature and the strip length carefully checked for permanent change. The same program was followed for $+200$, $+300$, and $+400^{\circ}\text{F}$.

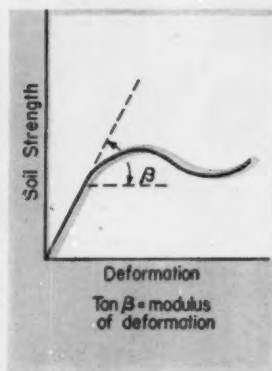
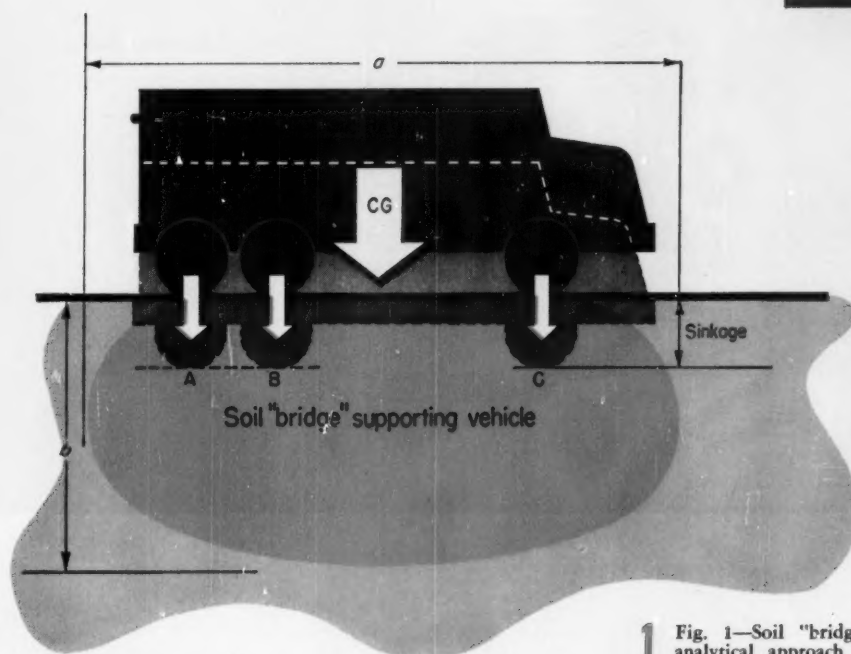
Results: As shown in Table 1, most elastomers expand and contract at rates slightly greater than ten times that of steel. Silicone elastomers change at significantly greater rates. Since friction in the jig would restrict movement of the rubber, it was made certain that the elastomer was free to move while under test.

Design Recommendations: Prolonged exposure to elevated temperatures results in permanent shrinkage. This phenomenon contributes to failure, with improper seal design and use of the wrong compound. If any thermal contraction takes place after the seal has acquired a 100 per cent compression set, contact will be lost and the seal will leak. The high thermal expansion rates of materials like silicones and Viton A may account for these materials effectively sealing systems at temperatures higher than tests indicate they should.

Thermal expansion can create tremendous forces. If a metal seal gland is completely filled with rubber, and heated, some allowance for expansion must be made, or the rubber will be volumetrically compressed due to its greater rate of thermal expansion. Since rubber is thought to be comparable with liquids in compressibility—that is, compressible under pressures of 30,000 to 50,000 psi—excessive pressures will be built up and failure may result. At the same time, properly designed seals will include allowance for the thermal contraction of the elastomer.

Table 1—Linear Thermal Expansion of Typical Elastomers and Common Alloys

Compound Base	Contraction +75 to -65°F (in./ft)	Expansion +75 to $+375^{\circ}\text{F}$ (in./ft)	Coefficient of Expansion (in./in./deg $^{\circ}\text{F}$)
Nitrile—General Purpose	0.104	0.224	6.2×10^{-5}
Chloroprene	0.128	0.273	7.6×10^{-5}
Viton-A	0.130	0.277	7.7×10^{-5}
Kel-F	0.140	0.300	8.3×10^{-5}
Silicone, Low-Temperature Type	0.173	0.370	10.3×10^{-5}
Silicone, High-Temperature Type	0.183	0.392	10.9×10^{-5}
Aluminum, 178-T	0.022	0.047	13.0×10^{-6}
Stainless Steel, Type 302	0.016	0.035	9.6×10^{-6}
Steel, Mild	0.011	0.024	6.7×10^{-6}
Invar	0.001	0.002	6.0×10^{-7}



1 Fig. 1—Soil "bridge" concept—the basis for new analytical approach to soil-vehicle evaluation.

Flotation and Motion Resistance

- Analysis
- Equations
- Practical Implications

M. G. BEKKER

Chief, Land Locomotion Research Laboratory
U. S. Army Ordnance
Tank-Automotive Command
Detroit, Mich.

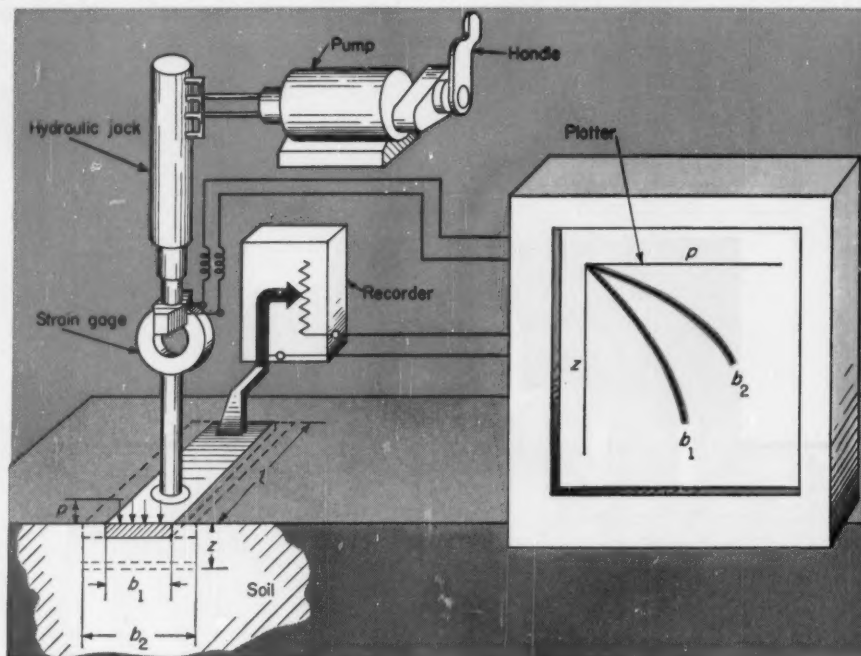
FOR off-the-road vehicles—earthmoving, logging, and farming—the ground is the medium which provides propelling forces.¹ It is also the source of resistance to motion. To properly assess any cross-country vehicle application, the amount of resistance imposed on the moving body by the soil must be analyzed. This resistance to motion is usually produced as the vehicle sinks into the soil. Hence, "sinkage" or "flotation" is a real measure of the amount of resistance offered by the soil. In this article, the general nature of sinkage and how it is determined is discussed, along with a procedure for analyzing motion resistance, using sinkage as a yardstick.

A New Approach

The problem of motion resistance is related to what is commonly referred to as *plastic deformation* of the soil under vehicle action. A rigorous solution to this problem has been impeded by a lack of work-

¹References are tabulated at end of article.

2 Plate-type tester for determining soil values.



able definitions of load-deformation functions which would reflect soil properties only, and which would not be affected by the size and shape of loading areas. A new engineering approach, which eliminates many of these obstacles, has been developed. Although it is not rigorous, this approach has established general semiempirical principles which aid in solving plasticity problems.

The heart of this new approach is the soil "bridge," Fig. 1, the characteristics of which are quite similar to conventional bridges of steel or concrete. To ascertain whether the soil bridge is strong enough to support a vehicle load without dangerous sinkage—corresponding to dangerous deflection in a conventional bridge—the geometry of the soil bridge, the load distribution, and the strength and modulus of elasticity of the soil must be determined.

Since elastic soils are by definition strong, they do not present difficult problems in off-the-road locomotion. Hence, the modulus of plasticity or modulus of deformation becomes the factor of primary concern. With this data, basic formulas defining the deformation of soil may be established in a manner similar to that used to develop equations for deformation of steel beams in a regular bridge. Thus, in a final analysis, equations can be written for determining whether the sinkage of the vehicle is safe, or whether it produces so much motion resistance that it would stop locomotion.

Equations for Sinkage

The horizontal reaction produced by the soil when it is deformed is soil thrust. Vertical forces of the

same origin produce, what is called in automotive parlance, vehicle "flotation," "sinkage," or in general, "soil compaction." Since the relationship between vertical loads and sinkage has not been defined theoretically, only approximate semiempirical solutions exist.²

In one of the oldest theories proposed,³ it was assumed that unit load (ground pressure) p acting on a footing is proportional to the square root of footing sinkage z :

$$p = kz^{1/2} \quad (4)$$

This theory has been expanded and a mathematical basis for vehicle motion resistance has been worked out:⁴

$$p = kz^n \quad (5)$$

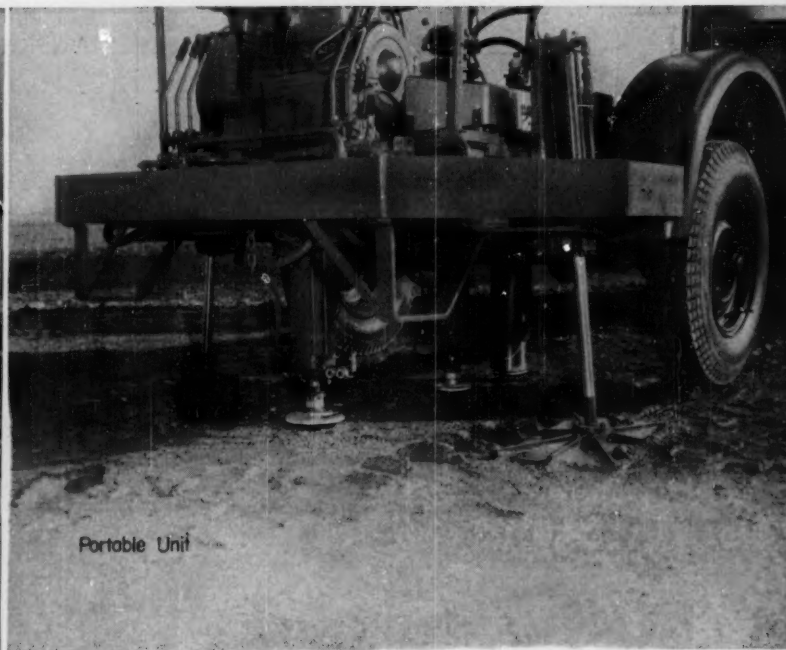
where n = exponent related to soil characteristics. Other relationships have been proposed,⁵ but all of these assumptions have been prohibitive in the development of a general theory of locomotion because k was a function of the wheel or tire size as well as the soil.

To avoid the inconvenience and practical limitations involved in using Equation 3 in footer sinkage, civil engineers⁶ have used

$$p = \left(\frac{k_c}{b} + k_\phi \right) z \quad (6)$$

where k_c = cohesive modulus, k_ϕ = frictional modulus, and b = width (smaller dimension) of loading area.

However, Equation 6 is valid only for relatively moderate sinkages. Hence, it cannot be used for



Photo, courtesy Caterpillar Tractor Co.

vehicle evaluation purposes since vehicles have a proportional sinkage which is greater than that for structures. A satisfactory soil-vehicle equation is obtained if Equation 5 and 6 are combined:

$$p = \left(\frac{k_c}{b} + k_\phi \right) z^n \quad (7)$$

Numerous experiments have shown that n , k_c , and k_ϕ are practically independent of the wheel or track size, and that Equation 7 may be used as a general basis of land locomotion mechanics.

Soil values k_c , k_ϕ and n define load-sinkage characteristics of a given soil under the action of a loading area. To determine these values, a rigid footing having area b by l is gradually loaded with a hydraulic jack which is actuated by a pump and controlled by a handle, Fig. 2. Thus the footing is forced to depth z , and instantaneous unit load W and corresponding sinkage z are measured with a strain gage and displacement recorder. The resulting curve is automatically plotted in p - z (or W - z) co-ordinates.

If the same procedure is repeated with two footings which have widths b_1 and b_2 , then two curves are obtained on the plotter, Fig. 2. A stationary laboratory-type instrument and an instrument for field measurements are also shown in Fig. 2.

A typical record made by such an apparatus is shown in Fig. 3. The graph shows load-sinkage curves of two plates: 5 by 2 in. and 5 by $\frac{3}{4}$ in. To process these curves, they must be expressed in terms of pressure-sinkage. Such values are computed by dividing the load by the area of the plate. Results of these tests are given in Table 1.

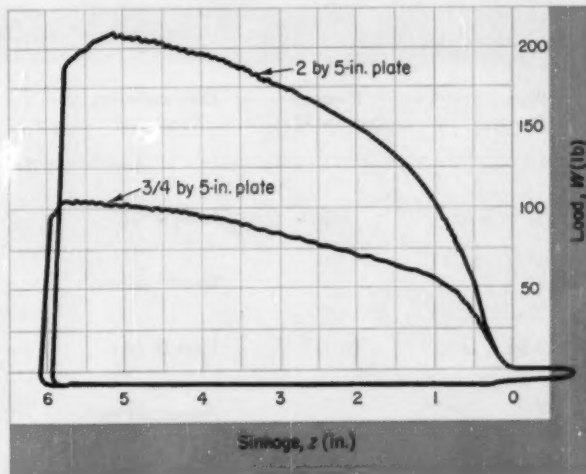
Equation 7 is used to write the expressions for the two curves shown in Fig. 3:

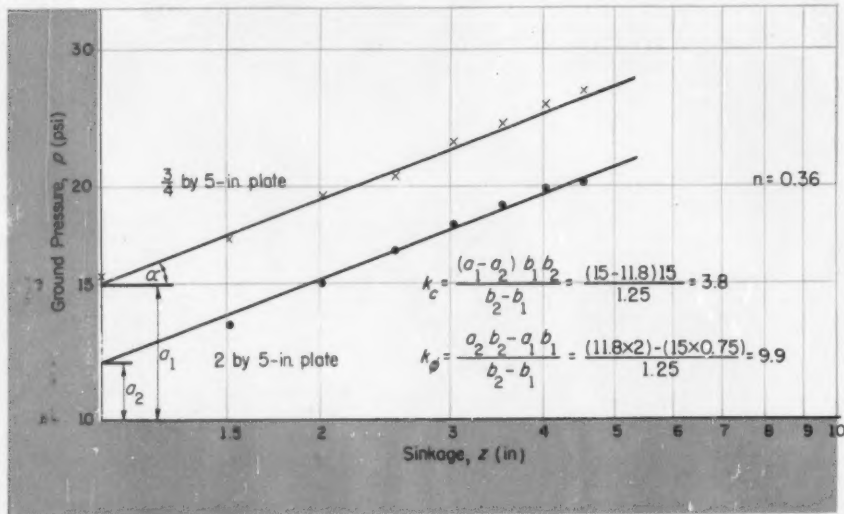
$$p_1 = \left(\frac{k_c}{2} + k_\phi \right) z^n \quad (8)$$

$$p_2 = \left(\frac{k_c}{\frac{3}{4}} + k_\phi \right) z^n \quad (9)$$

A third equation is obtained when either Equation

3 Area of supported surface has a direct effect on vehicle sinkage.





4 Graphic technique simplifies determination of soil values.

8 or 9 is expressed in logarithmic form. For example, Equation 8 becomes

$$\log p_1 = \log \left(\frac{k_c}{2} + k_\phi \right) + n \log z \quad (10)$$

Since pressures p_1 and p_2 have been determined for given values of z , Table 1, three equations exist with three unknowns: k_c , k_ϕ , and n . Hence, Equations 8, 9, and 10 can be solved to determine the unknowns. However, a graphical plot offers a simplified approach. When values of p and z from Table 1 are plotted on log-log paper, two straight lines are obtained as shown in Fig. 4. Slope α of one of these lines is, by definition of Equation 10, the n -value. Hence, $n = \tan \alpha$. Also, from Equation 10, intercepts a_1 and a_2 for Equations 8 and 9 are

$$a_1 = \frac{k_c}{2} + k_\phi \quad (11)$$

and

$$a_2 = \frac{k_c}{\frac{3}{4}} + k_\phi \quad (12)$$

Solution of Equations 11 and 12 yields:

$$k_c = \frac{2(\frac{3}{4})(a_1 - a_2)}{(2 - \frac{3}{4})} \quad (13)$$

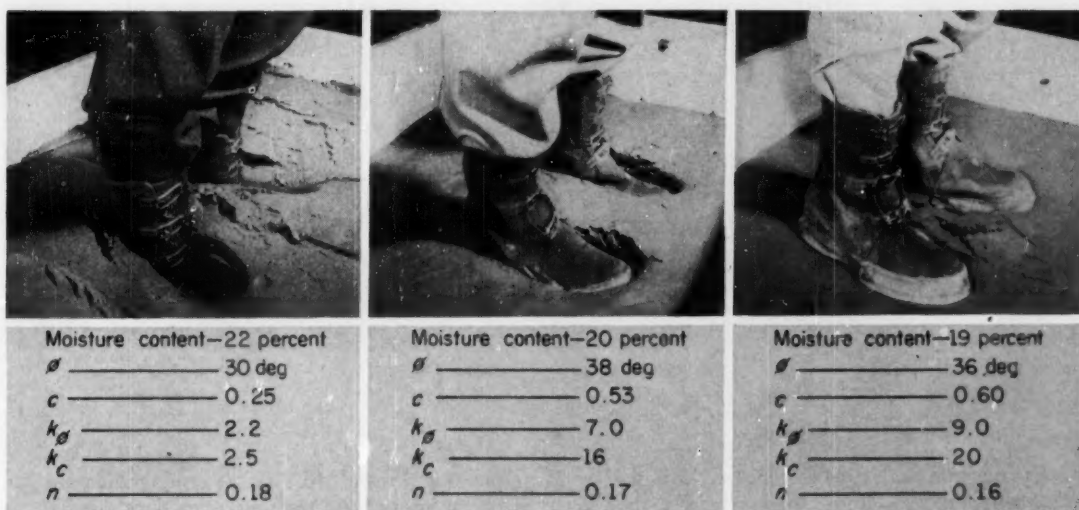
and

$$k_\phi = \frac{(2a_2 - \frac{3}{4}a_1)}{(2 - \frac{3}{4})} \quad (14)$$

Hence, values a_1 and a_2 can be measured directly from Fig. 4 and the unknown values k_c and k_ϕ can be determined from Equations 13 and 14.

Table 1—Soil Deformation Properties

Plate Size	Plate Area (in. ²)	Deformation Property	Sinkage, <i>z</i> (in.)								
			0.5	1	1.5	2.0	2.5	3.0	3.5	4.0	4.5
¾ by 5 in.	3.75	Load, <i>W</i> (lb)	35	57.5	65	72.5	77.5	85	90	95.5	99.5
		Pressure, <i>p</i> ₁ (psi)	9.35	15.3	17.3	19.3	20.6	22.7	24.0	25.5	26.5
2 by 5 in.	10	Load, <i>W</i> (lb)	50	100	132.5	150	165	177.5	187.5	197.5	202.5
		Pressure, <i>p</i> ₂ (psi)	5.0	10.0	13.2	15	16.5	17.7	18.7	19.7	20.2



5 Slight increases in the moisture content of soil can cause large changes in sinkage values.

Practical Soil Values

Variations of k_c , k_ϕ and n with moisture content in a sample soil are shown in Fig. 5. Values of c and ϕ are also shown to present a complete soil description from a trafficability viewpoint.

Soil values can vary quite extensively in the same specific area. The values in Table 2 illustrate such variations. All test samples were taken within the same 100 by 200-ft area.

Values k_c , k_ϕ and n are fundamentally parameters which fit the empirical curves. For practical purposes, k_c and k_ϕ are identified with the moduli of deformation. Term k_c is called the cohesive modulus of deformation, while k_ϕ is the frictional modulus of deformation. Exponent n reflects the effect of overburden and/or the stratification of soil.

Dry frictional soils, such as sand, usually show $k_c = 0$. Plastic, supersaturated, heavy clays show

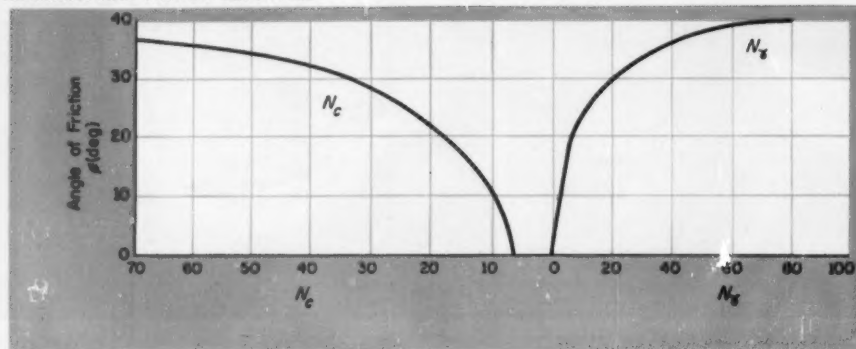
$k_\phi = 0$. Term n has values greater than zero, but usually less than 2, and changes with the depth of the soil layer if the layer rests on a hard stratum.

Techniques of measuring k_c , k_ϕ and n , like those related to the measurement of c and ϕ , must be determined for each specific application. The sizes of measuring plates and loads should ideally be the same as those for the actual vehicles. However, since the depth of soil affected by vehicle loads is relatively small (5 to 20 in.) soil at the affected depth and immediately below may be considered as homogeneous. Hence, small measuring plates and relatively small loads may be used. Normally, circular plates of 2 to 5-in. diameter suffice. Rectangular plates of 1 by 5 in. to 2 by 20 in. may also be used, but square plates should be avoided. For very soft soils, large plates are required and, for harder soils, small plates can be used. When vegetation

Table 2—Variations in Soil Values within Same Test Area

Soil Values	Lot Number									
	1	2	3	4	5	6	7	8	9	10
k_ϕ	4.3	2.9	3.9	3.3	0.6	0.7	4.5	4.3	2.2	2.5
k_c	5.4	3.3	10.8	13.1	28.8	29.4	1.8	2.7	1.8	2.7
n	0.27	0.27	0.28	0.28	0.29	0.29	0.27	0.27	0.42	0.42

6 Soil parameters which affect the safe load of the vehicle.



covers the soil, it is advisable to clear the test area, although this is not necessary if heavy test equipment is used.

In general, several measurements are necessary to determine a trend. Statistical character of changes in soils, even within a small area is obvious. However, a certain degree of consistency also cannot be denied. In any case, only the frequency distribution of values involved can give the true measure of soil characteristics.

Safe Load Formulas

Performance of off-the-road vehicles depends on their flotation, that is, on their ability to move on the soil surface without excessive sinkage, which produces motion resistance by compacting the ground.

The concept of flotation has been borrowed from hydrostatics and is thought to be analogous to the concept of buoyancy. However, the formulas for defining land-vehicle flotation are quite complicated because of the various unknowns involved. One of the most common equations used to define the safe load which can be supported by a rectangular footing is:^{7,8}

$$W = 21b(cN_c + \frac{1}{2}\gamma bN_\gamma) \quad (15)$$

where W = safe load, lb; b = footing width, in.; l = footing length, in.; c = cohesion, psi; γ = specific weight, lb per cu in. The terms N_c and N_γ are pure numbers, which depend on soil friction angle ϕ . Equation 15 gives the safe load for two tracks. Fig. 6 gives the relationship between N_c and N_γ for various values of ϕ .

If the bearing area is circular, such as that produced by a tire, Equation 15 becomes

$$W = n\pi r^2(1.3cN_c + 0.6\gamma rN_\gamma) \quad (16)$$

where n = number of wheels; and r = radius of circular bearing area, in. Load W is the safe weight for which the vehicle does not sink at all, beyond some insignificant elastic and/or elastic-plastic ground deformation. Hence, W defines the *surface crossing flotation*.

In most soils, however, vehicles usually sink when their loads exceed the value of W expressed by

Equations 15 and 16. To determine flotation for such a *subsurface crossing*, equations similar to Equations 15 and 16 are insufficient.

An equation for approximate static sinkage z of the ground contact area can be obtained from Equation 5:

$$z = \left(\frac{p}{\frac{k_c}{b} + k_\phi} \right)^{1/n} \quad (17)$$

If $p = W/2bl$ is assumed, Equation 17 becomes

$$z = \left[\frac{W}{2l(k_c + bk_\phi)} \right]^{1/n} \quad (18)$$

Equations 17 and 18 may be used to determine the approximate amount of sinkage, and hence, the amount of flotation in subsurface crossing.

Equations for Motion Resistance

Once the sinkage is determined, motion resistance due to compaction of soil may be determined. This type of resistance prevails in medium soils such as those encountered in agriculture and roadbuilding. Resistance encountered at high sinkage, in very loose soils resting on a hard stratum, or in muds must be determined in another manner.⁵

To determine the approximate compaction resistance, assume that a uniformly loaded track or low-pressure pneumatic tire sinks to depth z_0 , Fig. 7. Energy E' spent on compacting 1 sq in. of soil to depth z_0 is:

$$E' = \int_0^{z_0} p \, dz \quad (19)$$

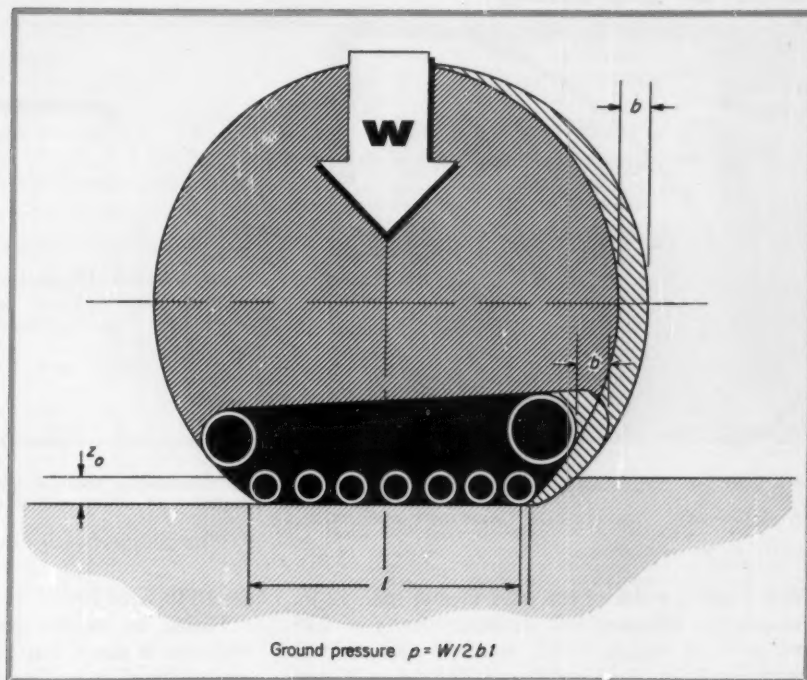
Hence, total energy expended on the whole contact area is

$$E = 21b \int_0^{z_0} p \, dz \quad (20)$$

The work or energy given by Equation 20 is wasted on distance l , equal to the length of the ground contact area, Fig. 7. Hence, motion resistance R_0 is obtained by dividing E by l . If $p = (k_c/b + k_\phi)z^n$ is assumed, Equation 20 becomes

$$R_0 = \frac{2(k_c + bk_\phi)^{-1/n} z_0^{n+1}}{n+1} \quad (21)$$

7 Geometric relationship between wheel-contact area and ground pressure.



If Equation 18 is substituted in Equation 21, the motion resistance is

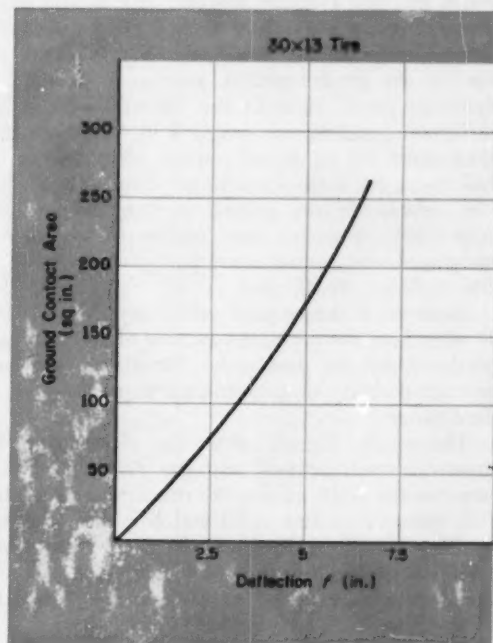
$$R_c = \left[\frac{2(k_c + bk_p)^{-1/n}}{n+1} \right] \left(\frac{W}{2l} \right)^{(n+1)/n} \quad (22)$$

Equation 15 and 16 give a fair degree of accuracy under the assumed conditions. And, since there is no better method in soil mechanics, no other solution is more accurate. Equations 17, 18, 21 and 22 have been rigorously tested and have been proven adequate. It is evident that the reproducibility of results predicted and measured depends on the homogeneity of soil, which can be controlled only in the laboratory. In the field, a large variation of soil values may occur from spot to spot, and the correlation of a large number of measurements with a pertinent number of predictions may only be satisfactory in a statistical sense.

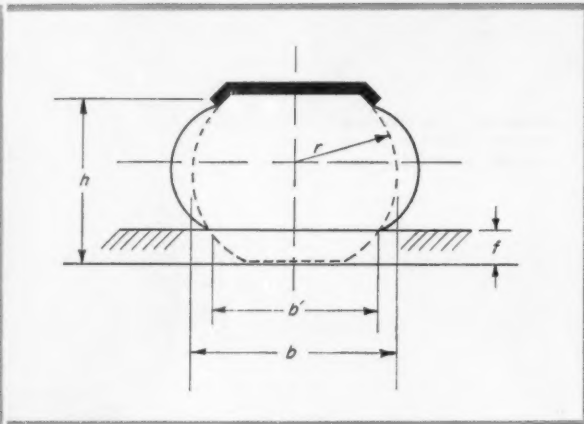
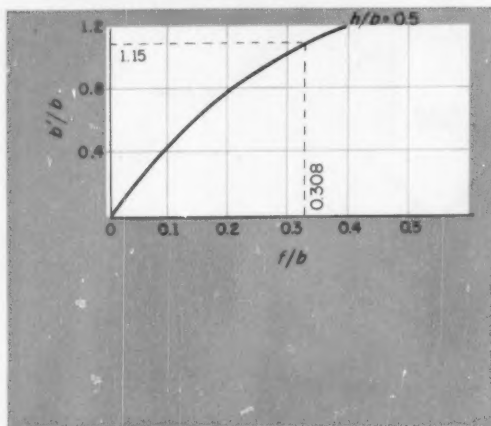
Examples

These equations, although they may be inaccurate by conventional standards, give a great deal of insight and guidance in the solution of land locomotion problems. For example, Equation 22 clearly indicates the advantage of having a long, narrow ground-contact area, because a smaller b and a larger l create smaller compaction resistance. This conclusion indirectly suggests that in off-the-road locomotion a large-diameter, narrow wheel will be better than a comparable small-diameter, wide one.

Example 1: Assume that a lightweight crawler-type tractor must be designed for operation on soft ground, with a ground-contact area less than



8 Ground-contact area is expressed as a function of deflection to help in calculating vehicle flotation.



9 Chart gives relationship between wheel contact width for on-the-surface flotation and wheel contact width for subsurface flotation.

50 in., and a width of the track greater than 12 in. Assume the following soil characteristics: $c = 0.75$ psi, $\phi = 30$ deg, $k_c = 30$, $k_\phi = 18$ and $n = 0.5$. From Fig. 6, $N_c = 35$ and $N_\gamma = 20$ for $\phi = 30$ deg. If $\gamma = 0.05$ lb per cu in., the safe load for on-the-surface operation is obtained from Equation 15:

$$W = 2(50)(12)[0.75(35) + 0.5(0.05)(12)(20)] \approx 39,000 \text{ lb}$$

The tractor then may be allowed to exert a ground pressure of

$$p = \frac{39,000}{2(50)(12)} \approx 32.5 \text{ psi}$$

Example 2: Since the ground pressure of 32.5 psi in Example 1 approaches that of a regular pneumatic tire, an alternative design using pneumatic tires should also be considered. Fig. 8 shows the size of the ground-contact area as a function of deflection for a 30 x 13 tire. Because of tire life, deflection f should not exceed 4 in. This can produce only 140 sq in. of contact area per tire, or 840 sq in. for a six-tire vehicle. Therefore, to float the vehicle on the ground surface without any appreciable sinkage, the previously determined weight of the vehicle must be reduced to $W = 840 \times 32.5 = 27,000$ lb.

However, if the original vehicle weight of 39,000 lb were kept the same, the amount of static sinkage produced by the tires under the above load, and the acceptability of this sinkage would have to be determined.

The chart, Fig. 9, gives the relationship for ground contact area b' and tire deflection f , and involves the width of the tire rim through the ratio h/b , where b = tire width and h = height of tire profile. The 30 x 13 tire is characterized by a rim width which produces $h/b = 0.5$. Since $b = 13$ in. and $f = 4$ in., ratio $f/b = 0.308$ and $b'/b = 1.15$. Hence $b' = 13 \times 1.15 = 15$ in.

Assuming that the ground contact area is formed by an ellipse, the area may be expressed by $A = 0.85 b'l$. Since $A = 140$ sq in. and $b = 12$ in.,

$$l = 140/0.85(15) = 11 \text{ in.}$$

Hence, the smaller dimension of the ground contact area is not b' but l . Therefore, the static sinkage obtained from Equation 18 is

$$z = \left\{ \frac{39,000}{2(13)[30 + 11(18)]} \right\}^2 > 20 \text{ in.}$$

This sinkage must be, of course, recognized as excessive. Accordingly, tire sizes must be recomputed in a similar way until the smallest tire which satisfies the requirements is obtained.

Example 3: Assume that a standard vehicle equipped with 10-in. wide tracks and having ground pressure $p = 10$ psi is unsatisfactory. Accordingly, to increase the pulling force, the weight of the tractor is increased. In addition, to offset the disadvantages of a heavier machine, ground pressure is reduced to $p = 7.5$ psi by increasing the track width to $b = 20$ in. Length of the ground-contact area $l = 50$ in. is retained.

The proving ground in which this design change was first tested showed deterioration of performance rather than improvement. The new low-ground-pressure vehicle sank more and pulled less unit of its weight than the original one. With the determined soil values, $k_c = 30$, $k_\phi = 1$, and $n = 0.5$, the sinkage of the two tracks was determined from Equation 17. For the 10-in. track,

$$z_{10} = \left(\frac{10}{\frac{30}{10} + 1} \right)^{1/0.5} \approx 6.25 \text{ in.}$$

For the 20-in. track

$$z_{20} = \left(\frac{7.5}{\frac{30}{20} + 1} \right)^{1/0.5} \approx 9 \text{ in.}$$

Equation 21 indicates that the higher sinkage produces more motion resistance R_c , which deteriorates vehicle performance. For 10-in. track,

$$R_c = \frac{2(30 + 10)6.25^{1.5}}{1.5} \approx 1260 \text{ lb}$$

For the 20-in. track

$$R_c = \frac{2(30 + 20)^{91.5}}{1.5} \approx 2720 \text{ lb}$$

The safe loads on the tracks were $W_{10} = 2 \times 10 \times 50 \times 10 = 10,000 \text{ lb}$ and $W_{20} = 2 \times 20 \times 50 \times 7.5 = 15,000 \text{ lb}$. Hence, unit motion resistance was increased despite the lowering of the ground pressure by 44.5 per cent:

$$100 \left[\frac{\left(\frac{R_c}{W} \right)_{20} - \left(\frac{R_c}{W} \right)_{10}}{\left(\frac{R_c}{W} \right)_{20}} \right]$$

$$= 100 \left[\frac{\left(\frac{2720}{15000} \right) - \left(\frac{1260}{10000} \right)}{\left(\frac{2720}{15000} \right)} \right] \approx 44.5 \text{ per cent}$$

This reduced the maximum drawbar pull and also increased fuel consumption.

Hence, an economic operation of tractors and

carriers cannot be achieved on the basis of presently used yardsticks, but must be based on the knowledge of pertinent soil values.

REFERENCES

1. M. G. Bekker—"Thrust for Propulsion," *MACHINE DESIGN*, Vol. 31, No. 26, December 24, 1959, pp. 92-98.
2. M. G. Bekker—"Mechanics of Vehicle Mobility in Off-the-Road Locomotion," *Applied Mechanics Reviews*, Vol. II, No. 8, 1958.
3. R. Bernstein—"Probleme sur experimentellen Motorflugmechanik" (Problems of Experimental Mechanics of Motor Ploughs), *Der Motorwagen*, No. 16, 1913.
4. M. N. Letoshnev—"Kolanye Povorzi . . ." (Wheeled Vehicles), *Teoriya i proizvodstvo stelskookoyaznits* (Theory and Production of Agricultural Machinery), Moscow, 1936.
5. M. G. Bekker—"Theory of Land Locomotion—The Mechanics of Vehicle Mobility," University of Michigan Press, Ann Arbor, Mich., 1956.
6. M. G. Bekker—"A System of Physical and Geometrical Soil Values for the Determination of Vehicle Performance and Soil Trafficability," *Proc. Interservice Symposium*, Stevens Institute of Technology—Duke University, Office of Ordnance Research Land Locomotion Laboratory, OTAC, Detroit, 1955.
7. E. W. W. Micklethwait—"Soil Mechanics in Relation to Fighting Vehicles," Military College of Science, Ministry of Supply, London, 1944.
8. K. Terzaghi—"Theoretical Soil Mechanics," John Wiley & Sons Inc., New York, N. Y., 1944.
9. J. Rotta—"Zur Statik des Luftreifens," (Statics of a Pneumatic Tire) *Ingenieur Archiv* Vol. XVII, 1949.
10. M. G. Bekker—"Introduction to Research on Vehicle Mobility," Canadian Dept. of National Defense, Ottawa, 1948; US Ord. Corps, Aberdeen Proving Ground, Maryland, 1951; Land Locomotion Laboratory, Ordnance Tank-Automotive Command, 1957.

Tips and Techniques

Selecting Spring Proportions

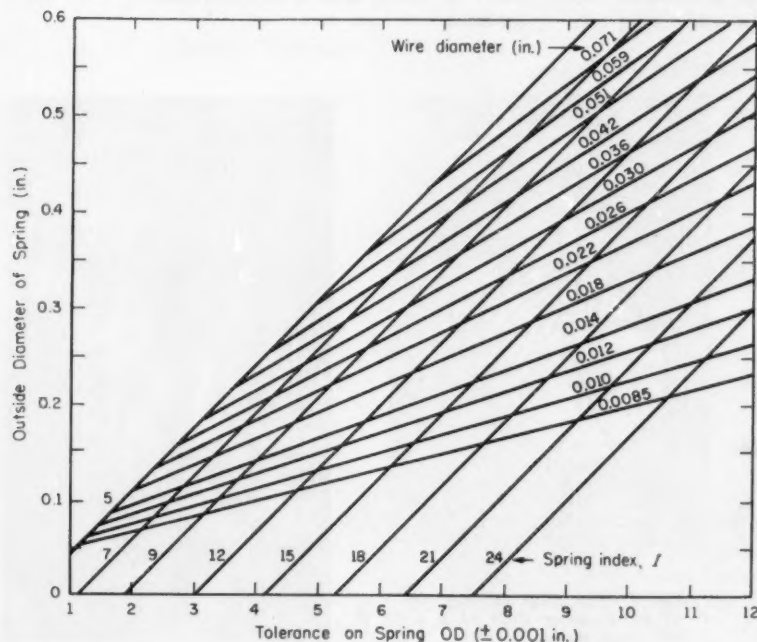
A chart for designing helical music-wire springs, based upon the outside diameter, is an aid to the designer concerned with space limitations. Frequently, this

type of chart is based upon the mean diameter, and the outside dimensions of the spring are not apparent.

The chart is based on use of the spring index, $I =$

D/d where I = spring index; D = mean diameter of spring, in.; and d = wire diameter, in. Spring index should not be less than 5, and is preferably 7 or more. Outside diameter is $d(I + 1)$.

To use the chart, begin with the known data, following the chart lines to the intersection which will yield the desired information. If the OD is known, for instance, follow the horizontal lines to the intersection of the known spring index to find the required wire diameter. Similarly, if wire diameter and index are known, the final OD can be found. The tolerances shown are for close-wound springs of music wire. Open-wound spring tolerances are 0.005 in. larger in every case. The chart is intended for quick approximations and not exact results. — **FREDERICK H. TYLER**, mechanical engineer, Dayton, Ohio.



Tips and Techniques

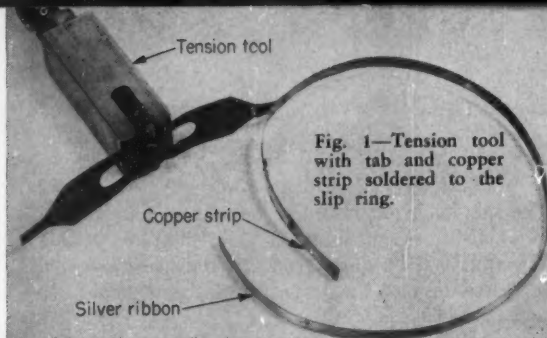
Silver ribbon forms

Simple Slip Rings

... for strain gage measurement

J. VALENTICH

Materials Engineering Laboratory
Westinghouse Electric Corp.
Pittsburgh, Pa.



STRESS analysis by strain gaging of rotating equipment frequently requires a fast and simple installation of a temporary slip ring on a shaft. After SR-4 strain gages are attached to the shaft, stresses then can be interpreted from oscilloscope traces. The slip ring allows the signal to be picked up from the strain gage which is rotating with shaft.

The shaft is first prepared by gluing the strain gage at the desired position and orientation with any of the usual bonding agents. Glass tape is then wound in layers around the circumference of the shaft at the slip-ring location as an insulator. Lead wires from the gages are then brought to the ring in channels cut through the tape's outer layers. The ring, Fig. 1, is assembled on the shaft, under tension, with the tool shown, Fig. 3. After the silver ribbon is checked for position and tension, its free end is cut off and soldered to the underlying cop-

per strip in a butt joint. The gage lead wires are also soldered to this strip. Brushes of 3/16 in. square material (composition, 60 per cent silver, 40 per cent graphite) are mounted in a laminated plastic holder block, together with their springs. Four such brush-holders are required to reduce noise level on each slip ring to acceptable levels. After the mechanical parts have been assembled, the system is hooked up in a bridge circuit. Strain data can then be read directly from a calibrated oscilloscope.

This method has been used on shafts up to 35 in. in diameter. Speeds varied up to 4250 fpm, with the rings 0.003 in. out of round at this speed. Careful attention given to filing the butt joint of the ribbon true after unsoldering the tightening tool is important. Ribbon dimensions were 1/4 in. wide x 0.011 in. thick, with a copper soldering strip 0.005 in. thick.

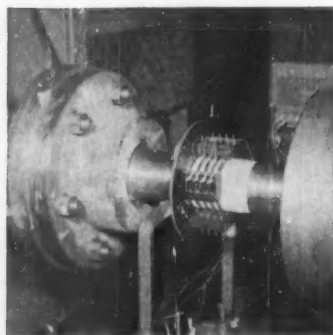


Fig. 2—Calibrated torsion shaft coupled between 600 H.P.D.C. mill motor and generator.

Fig. 3—Slip ring being stretched around shaft.

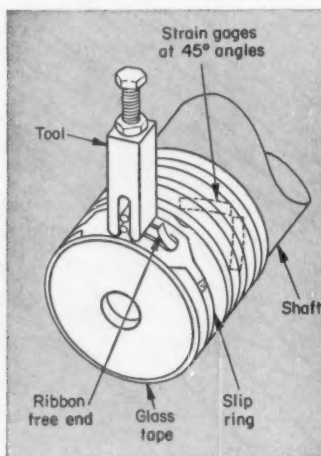
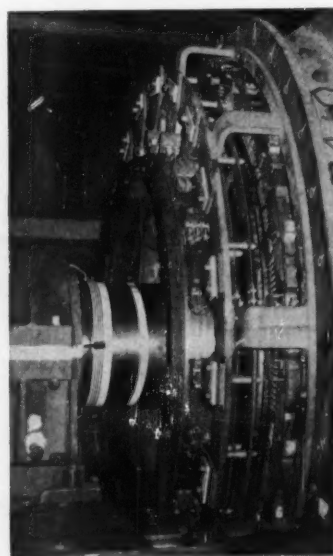


Fig. 4—Slip rings mounted on a 35 in. diameter shaft of a 6000 H.P. mill motor.



Four ways to calculate

Planetary Gear Trains

- Energy Method
- Graphical Method
- Relative-Velocity Method
- Tabular Method

WILLIAM H. WILKINSON

Assistant Consultant,
Mechanical Research Div.
Battelle Memorial Institute
Columbus, Ohio

PLANETARY gear trains can become complicated. Motions of components and their relationships are not always apparent. Thus, analyzing planetary gear trains is not a "handbook" matter; basic understanding is required. Four methods of general approach presented here give this fundamental insight. Of the four, the graphical method is best for quick checks.

Energy Method

In the simple planetary system, Fig. 1, assume

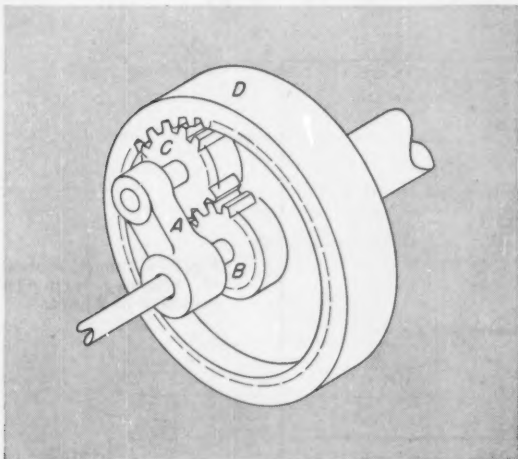


Fig. 1—Simple planetary gear train.

sun gear *B* and internal gear *D* are the driving members and rotate in the same direction, clockwise. Planet carrier *A* is the load member. A free-body diagram of the planet gear is shown in Fig. 2; V_{DC} and V_{BC} are the absolute velocities at each mesh point, V_A is the absolute velocity of the planet gear center, and F_{DC} , F_{BC} , and F_A are the corresponding forces.

By summation of moments about the center,

$$F_{DC} = F_{BC} \quad (1)$$

and by summation of forces,

$$F_A = 2F_{BC} \quad (2)$$

For the velocity directions shown in Fig. 2, power-flow relationship is

$$F_{BC} V_{BC} = F_A V_A - F_{DC} V_{DC} \quad (3)$$

Since planet carrier *A* and gears *B* and *D* have a common center of rotation,

$$\omega_A = \frac{V_A}{R_B + R_C} \quad (4)$$

$$\omega_B = \frac{V_{BC}}{R_B} \quad (5)$$

$$\omega_D = \frac{V_{DC}}{R_D} \quad (6)$$

where ω and R represent absolute angular velocity and pitch radius, respectively, of the system elements identified by subscript.

Substituting Equations 1, 2, 4, 5, and 6 into Equation 3, simplifying, and solving for ω_B ,

$$\omega_B = (M + 1)\omega_A - M\omega_D \quad (7)$$

where

$$M = \frac{R_D}{R_B} \quad (8)$$

For the normal operating condition where ring gear D is fixed, $\omega_D = 0$ and

$$\omega_B = (M + 1)\omega_A \quad (9)$$

The parameter, M , has particular significance in generalized expressions where sign conventions are necessary.

Graphical Methods

When internal gear D of the simple planetary train, Fig. 1, is held against rotation, velocity diagram for the system can be constructed as shown in Fig. 3a. In this diagram, velocity is the abscissa, and radial distance along the line connecting the centers of gears B and C is the ordinate.

This construction is based on the same principles used for velocity analysis of other mechanisms. Instant centers for gear B and carrier A are at the shaft center while the instant center for gear C is at the mesh pitch point for gears C and D .

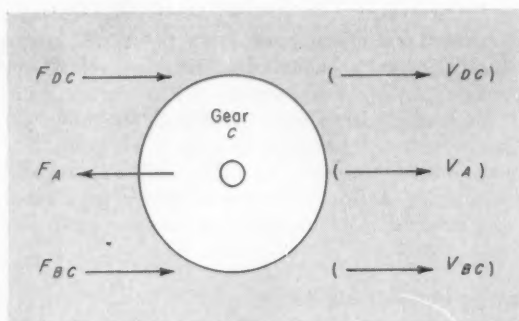


Fig. 2—Free-body diagram of gear C in Fig. 1, showing forces and velocities used for analysis by energy method.

From Fig. 3a,

$$V_A = \frac{V_{BC}}{2} \quad (10)$$

and from angular-velocity relationships given by Equations 4 and 5,

$$\begin{aligned} \frac{\omega_B}{\omega_A} &= \frac{2V_A}{V_A} \left(\frac{R_B + R_C}{R_B} \right) \\ &= \frac{2(R_B + R_C)}{R_B} = \frac{R_D + R_B}{R_B} \end{aligned} \quad (11)$$

which is the same as Equation 9.

For the more general case, Fig. 3b, considering only the shaded triangular section,

$$V_A - V_{CD} = \frac{V_{BC} - V_{CD}}{2} \quad (12)$$

Solving for V_A , V_{BC} , and V_{DC} in Equation 4, 5, and 6 and substituting into Equation 12 gives

$$2(R_B + R_C)\omega_A - \omega_D R_D = \omega_B R_B \quad (13)$$

which, when rearranged, becomes Equation 7.

The greatest advantage of this method lies in its usefulness for quick qualitative analysis. For example, in Fig. 3a,

$$\begin{aligned} \tan \phi_B &= \frac{V_{BC}}{R_B} = \omega_B \\ \tan \phi_A &= \frac{V_A}{R_B + R_C} = \omega_A \end{aligned}$$

Thus, the relative size of the angles, ϕ , gives a direct indication of velocity relationships in the system.

Relative-Velocity Method

If the rotations of all the gears in the simple planetary system, Fig. 1, are observed from a station on the planet carrier, the apparent rotation of gears D and B can be calculated by conventional methods. Thus,

$$\frac{\omega_{B \rightarrow A}}{\omega_{D \rightarrow A}} = -\frac{R_D}{R_C} \frac{R_C}{R_D} = -\frac{R_D}{R_B} = -M \quad (14)$$

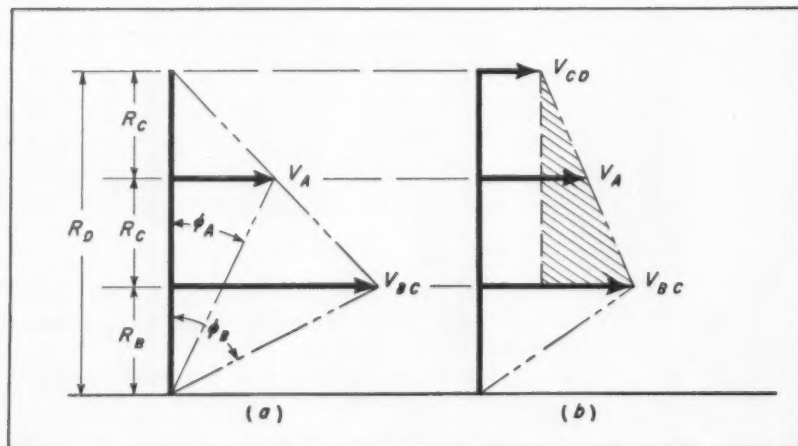


Fig. 3—Graphical method of analyzing simple planetary of Fig. 1.

where $\omega_{B \rightarrow A}$ and $\omega_{D \rightarrow A}$ are velocities of gears B and D , respectively, relative to planet-carrier A . However,

$$\omega_{B \rightarrow A} = \omega_B - \omega_A \quad (15)$$

$$\omega_{D \rightarrow A} = \omega_D - \omega_A \quad (16)$$

Substituting these equivalents into Equation 14, gives

$$\omega_B - \omega_A = -M(\omega_D - \omega_A) \quad (17)$$

which, when rearranged, becomes Equation 7.

The significance of parameter M becomes apparent in this approach, since Equation 14 shows it to have real meaning. In fact, the speed ratio, or train value, with the planet-carrier fixed against rotation, as it has been considered here, is the most easily distinguished characteristic of the simple planetary system.

Tabular Method

This method is the one most frequently found in the literature. Although based on the same concepts as the previous method, it is quite different in execution, involving three distinct steps, Table 1.

Step 1: Assume planet carrier is fixed. Rotate gear B through X turns (usually $X = 1$ for convenience) and determine corresponding number of turns for all other gears in train.

Step 2: Assume all gears locked in mesh. Rotate arm of planet carrier through arbitrary angle.

Step 3: Add motions determined in steps 1 and 2 to find total angular motion θ for each of the train elements.

For the simple planetary train, Fig. 1, motion equations for gears B and D and planet carrier A can be determined directly from Table 1:

$$\theta_A = \alpha \quad (18)$$

$$\theta_B = X + \alpha \quad (19)$$

$$\theta_D = \alpha - \frac{R_B}{R_D} X = \alpha - \frac{X}{M} \quad (20)$$

Combining Equation 18, 19, and 20 and simplifying,

$$\theta_B = (M + 1)\theta_A - M\theta_D \quad (21)$$

Differentiating this expression to find angular velocity ($d\theta/dt = \omega$) gives Equation 7.

Compound Planetary Train

To provide a better basis for comparison, application of each of the four methods under more demanding calculation requirements will be demonstrated.

Consider the differential-planetary arrangement shown in Fig. 4a. Sun gear B meshes with planet gear C , which meshes with internal gear D . Planet gears C and E are keyed to a common shaft which is supported by planet carrier A but is free to rotate. Planet carrier A rotates freely about the shaft on which sun gear B is mounted. External power connections are provided at internal gear F which meshes with planet gear E , internal gear D , and sun gear B .

Energy Method: Free-body diagrams of the planet gear assembly is shown at Fig. 4b; gears B and D are assumed to be the driving members, which are rotating in the same direction (clockwise), and gear F is the driven member. Since the planet carrier is not a load member in this arrangement, $F_A = 0$. By summation of moments about axis 1 (mesh point of gears C and D),

$$F_{EF}(R_C - R_E) = F_{BC}(2R_C) \quad (22)$$

Similarly, by summation of moments about axis 2 (mesh point of gears E and F),

$$F_{CD}(R_C - R_E) = F_{BC}(R_C + R_E) \quad (23)$$

Power flow relationship is

$$F_{BC}V_{BC} + F_{CD}V_{CD} = F_{EF}V_{EF} \quad (24)$$

By definition,

$$V_{BC} = R_B\omega_B \quad (25)$$

$$V_{EF} = R_F\omega_F \quad (26)$$

$$V_{CD} = R_D\omega_D \quad (27)$$

Combining Equations 22 through 27 and using the

Table 1—Tabular Method of Planetary-Train Analysis

	Planet-Carrier A	Revolutions Gear B	Gear C	Gear D
Step 1	0	X	$-\frac{R_B}{R_C} X$	$-\frac{R_C}{R_D} \frac{R_B}{R_C} X$
Step 2	α	α	α	α
Sum	α	$X + \alpha$	$\alpha - \frac{R_B}{R_C} X$	$\alpha - \frac{R_B}{R_D} X$

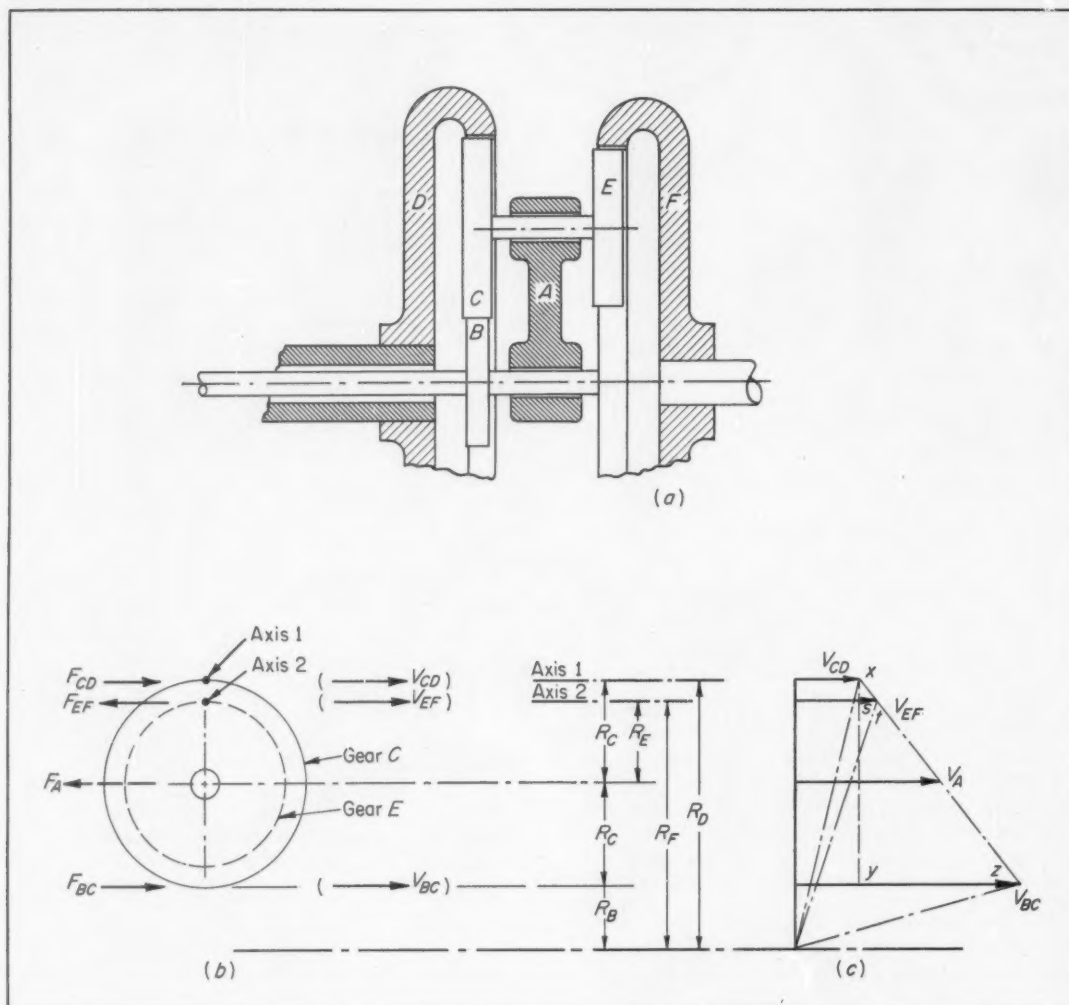


Fig. 14—Compound planetary train, *a*, with forces and velocities, *b*, and graphical analysis method, *c*.

Table 2—Tabular Analysis of Differential Planetary Train

	Planet Carrier A	Gear B	Revolutions Gears C and E	Gear D	Gear F
Step 1	0	X	$-\frac{R_B}{R_C} X$	$+\frac{R_C}{R_D} \left(-\frac{R_B}{R_C}\right) X$ $= -\frac{X}{\psi}$	$+\frac{R_B}{R_F} \left(-\frac{R_B}{R_C}\right) X$ $= -\frac{X}{\beta}$
Step 2	α	α	α	α	α
Sum, θ	α	$X + \alpha$	$-\frac{R_B}{R_C} X + \alpha$	$-\frac{X}{\psi} + \alpha$	$-\frac{X}{\beta} + \alpha$

relationship, $2R_C = R_D - R_B$, to simplify results,

$$\begin{aligned}\omega_B + \left(\frac{R_C + R_E}{R_C - R_E} \right) \left(\frac{R_D}{R_B} \right) \omega_D \\ = \left(\frac{R_D - R_B}{R_C - R_E} \right) \left(\frac{R_F}{R_B} \right) \omega_F\end{aligned}\quad (28)$$

Graphical Method: Velocity diagram for the differential train is shown at Fig. 4c. From similar triangles xyz and xst ,

$$V_{BC} - V_{CD} = \frac{2R_C}{R_C - R_E} \cdot (V_{EF} - V_{CD}) \quad (29)$$

Combining Equations 25, 26, and 27 with Equation 29 and simplifying gives Equation 28.

Relative-Velocity Method: With the planet carrier as the point of reference,

$$\frac{\omega_{B \rightarrow A}}{\omega_{D \rightarrow A}} = - \frac{R_D}{R_B} = \frac{\omega_B - \omega_A}{\omega_D - \omega_A} \quad (30)$$

and

$$\frac{\omega_{B \rightarrow A}}{\omega_{F \rightarrow A}} = - \frac{R_F R_C}{R_E R_B} = \frac{\omega_B - \omega_A}{\omega_F - \omega_A} \quad (31)$$

where ω_A is the angular velocity of the planet carrier. In reduced form, these two equations become

$$\omega_A = \left(\frac{R_B}{R_D + R_B} \right) \omega_B + \left(\frac{R_D}{R_D + R_B} \right) \omega_D \quad (32)$$

$$\left(1 + \frac{R_F R_C}{R_E R_B} \right) \omega_A = \omega_B + \left(\frac{R_F R_C}{R_E R_B} \right) \omega_F \quad (33)$$

Next logical step would appear to be elimination of ω_A by substitution. However, this operation leads to a pair of complex fractional coefficients in terms of the different radii and illustrates a pitfall that should be avoided. Although the resulting expression could be reduced to the form of Equation 28, the algebraic operations required are tedious and time consuming. Another approach is needed.

Equations 30 and 31 represent train values, or speed ratios, with the planet-carrier stationary. Let

$$-\psi = \frac{\omega_B - \omega_A}{\omega_D - \omega_A} = - \frac{R_D}{R_B} = - \frac{N_D}{N_B} \quad (34)$$

and

$$-\beta = \frac{\omega_B - \omega_A}{\omega_F - \omega_A} = - \frac{R_F R_C}{R_E R_B} = - \frac{N_F N_C}{N_E N_B} \quad (35)$$

where ψ and β are the "relative train values" which are defined in terms of radii R or numbers of teeth N . Combining Equations 34 and 35 and simplifying gives

$$\omega_B + \frac{\psi(1 + \beta)}{\beta - \psi} \omega_D = \frac{\beta(1 + \psi)}{\beta - \psi} \omega_F \quad (36)$$

which is a much more convenient expression to handle in calculations.

Tabular Method: Results of the three-step tabulation procedure are given in Table 2.

From these results,

$$\frac{\omega_D}{\omega_B} = \frac{-\frac{X}{\psi} + \alpha}{X + \alpha} \quad (37)$$

and

$$\frac{\omega_F}{\omega_B} = \frac{-\frac{X}{\beta} + \alpha}{X + \alpha} \quad (38)$$

Solving for α in Equation 37 and substituting this expression into Equation 38 gives Equation 36 when reduced to the simplest form.

Comparative Results: To illustrate the relation between the two forms of solution, Equations 28 and 36, a set of arbitrary sizes for the gears will be assumed: $N_B = 15$, $N_C = 30$, $N_D = 75$, $N_E = 29$, and $N_F = 74$. For diametral pitch $P_d = 5$, $R_B = 1.5$ in., $R_C = 3$ in., $R_D = 7.5$ in., $R_E = 2.9$ in., and $R_F = 7.4$ in.

From Equation 28,

$$\omega_B + 295 \omega_D = 296 \omega_F \quad (39)$$

From Equation 35, $\beta = 5 \frac{3}{29}$ and from Equation 34, $\psi = 5.0$. Substituting these values into Equation 36 gives the same result (Equation 39) obtained previously with Equation 28.

The main variation in two forms of solution is the difference term in the denominator of the coefficients for ω_D and ω_F . Two gears of nearly the same size are involved in one solution (Equation 28) and two nearly equal gear ratios in the other (Equation 36).

Another point for comparison of the two forms of solution can be illustrated by considering the effect of slight variations in gear dimensions. A common technique for varying the reduction in a planetary gear train is to purposely machine either more or less teeth in one of the internal gears. For example, gear F might be made with only 73 teeth rather than 74.

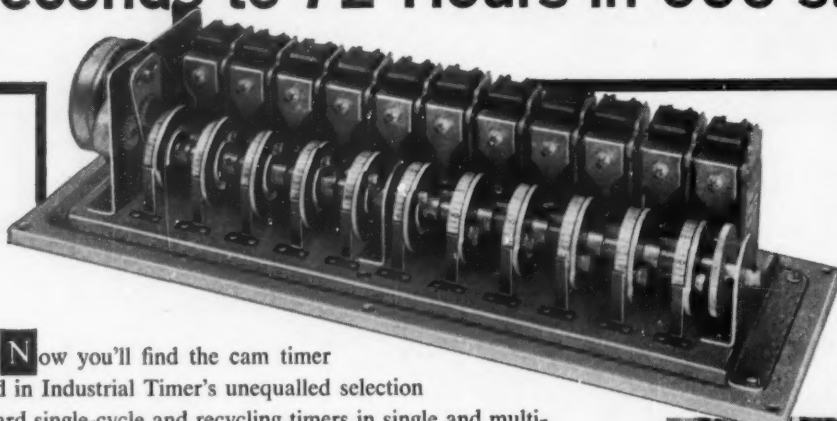
The effect of this variation is clearly apparent from Equation 36 where gear ratio β becomes $5 \frac{1}{29}$ and the value of difference term, $\beta - \psi$, is only $\frac{1}{3}$ of its previous value.

The actual modification, however, is more subtle than has been indicated in that the true diametral pitch for gears E and F becomes 4.88889 even though a 5-pitch cutter could probably still be used. This change is shown in Equation 28 where R_E becomes 2.9659 in. and the value of the difference term, $R_C - R_E$, becomes 0.0341, almost $\frac{1}{3}$ of the previous value.

Of all of the methods discussed, only the graphical method provides a quick visual picture of velocity relationship in the system. This feature can often be advantageous in design analysis where a quick check on the effect of different operating conditions is required.

THE WIDEST RANGE OF CAM TIMERS AND TIME CYCLES

2/3 Seconds to 72 Hours in 600 steps



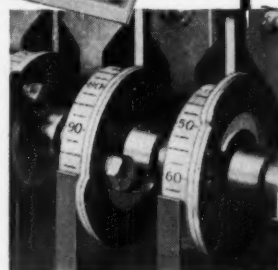
Now you'll find the cam timer you need in Industrial Timer's unequalled selection of standard single-cycle and recycling timers in single and multi-switch types (up to 50 switches). Every model gives you 50 different overall time cycles, ranging from its lowest cycle up to 9 times that cycle. And standard cam construction lets you adjust ON and OFF periods from 2% to 98% of the total time cycle. Here is unsurpassed flexibility in cam timer selection and function.



If you don't find the timer you want in this unmatched range (a highly unlikely possibility), Industrial Timer's unique Timer Kit will help provide the exact timer you need at low cost. With this kit you can design your own prototype, and since the kit components are standard in our line we can reproduce your prototype—in quantity—at no extra cost.

For fast delivery on a standard or special Cam Timer check first with Industrial Timer. For more information ask for *Bulletin 200* Synchronous Motor Driven Cam Timers, *Bulletin 201* Multi-Cam Timer Kit, *Bulletin 202* Multi-Cam Switching Devices.

Industrial Timer's complete line of timers also includes: Time Delay Timers, Interval Timers, Running Time Meters, and Programmers. Bulletins describing these are available on request.



*Timers that Control
the Pulse Beat of Industry*

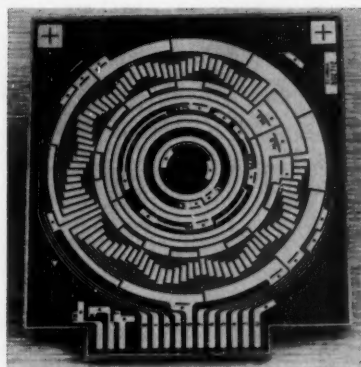


INDUSTRIAL TIMER CORPORATION

1413 McCARTER HIGHWAY, NEWARK 4, N. J.

*Capabilities and limitations
of three processes for making—*

Flush Printed Circuits



Part of an analog-to-digital converter produced as a flush-printed circuit.

Fig. 2—Operations in the molding process.

LEROY N. CHELLIS

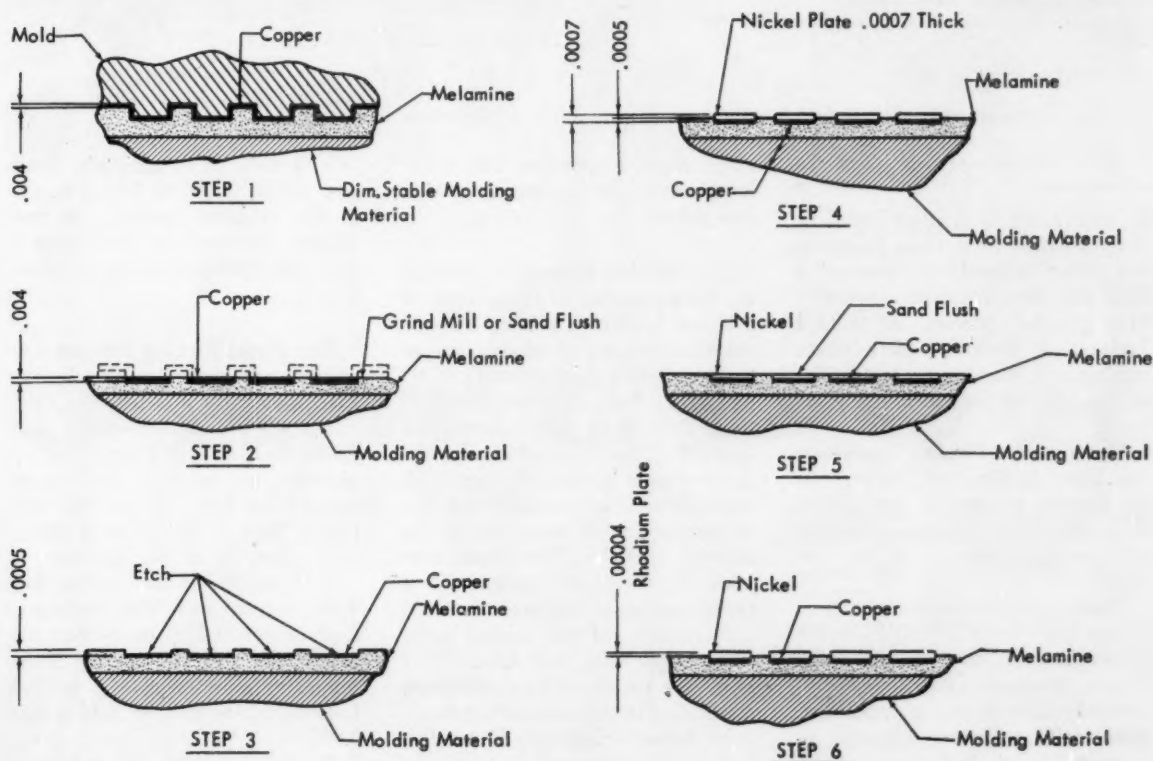
Development Engineer
International Business Machines Corp.
Endicott, N. Y.

FROM current data and experience, there are certain basic requirements which a flush circuit must meet if it is to provide reliability and long life. These requirements are:

1. The circuit must be flush with its supporting base within 0.0001 to 0.0002 in. to minimize wiper wear or bounce.
2. That portion of the circuit subject to wear by wiping contacts must be overlaid with a hard, wear-resistant

metal. A thickness of 0.0005 in. of nickel and 0.000030 to 0.000040 in. of rhodium is often specified.

3. The surface of the circuit must carry a high finish to promote maximum wear life of the wiper contacts. Surface finish should be 6 microinches or finer.
4. Sharp line definition and accurate registration may be very important where the device requires accurate timing.
5. Adhesion of the conductors to the base material must be somewhat better than that normally associated with printed circuits. Pull strengths of 10 to 15 lb per inch of width are usually specified.
6. The plastic insulating base must be dimensionally stable and should have



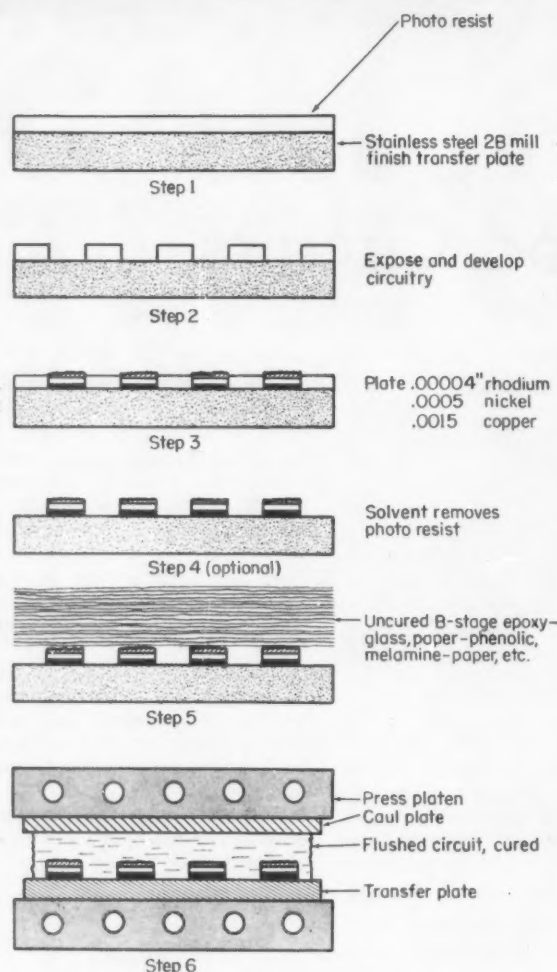


Fig. 1—Operations in the transfer process.

good resistance to wear from the contacts.

In computers and data-handling equipment, at least three processes are being utilized for producing flush circuitry. These processes are: The transfer process, a molded flush-circuit process, and a direct etching and flushing process utilizing copper-clad laminates.

The Transfer Process: Operations are shown in Fig. 1. Advantages of the transfer process are availability of a wide variety of base materials and extreme flushness of the circuitry.

Disadvantages include inability to obtain high surface finish on the plated rhodium. With present techniques, rhodium cannot be commercially plated on high-polished plates with sufficient adhesion to prevent "drift" during the subse-

quent transfer operation. The transfer plates require constant cleaning and refinishing.

The Molded Process: Operations are shown in Fig. 2. Preparation of a circuit begins by placing a single particle thickness of copper powder on copper foil approximately 0.003 in. thick, then sintering at 1600 to 1900 F. The plastic insulating material is then molded against the sintered side of the foil, Step 1. A mechanical bond is established due to interlocking of resin around the sintered particles. The mold contains the circuit configuration as a raised portion of the force or cavity.

Advantages of the molded process are low cost, and adaptability to a wide variety of base insulating materials. Outside contours, through holes, bosses, or lugs may be molded-in during the process.

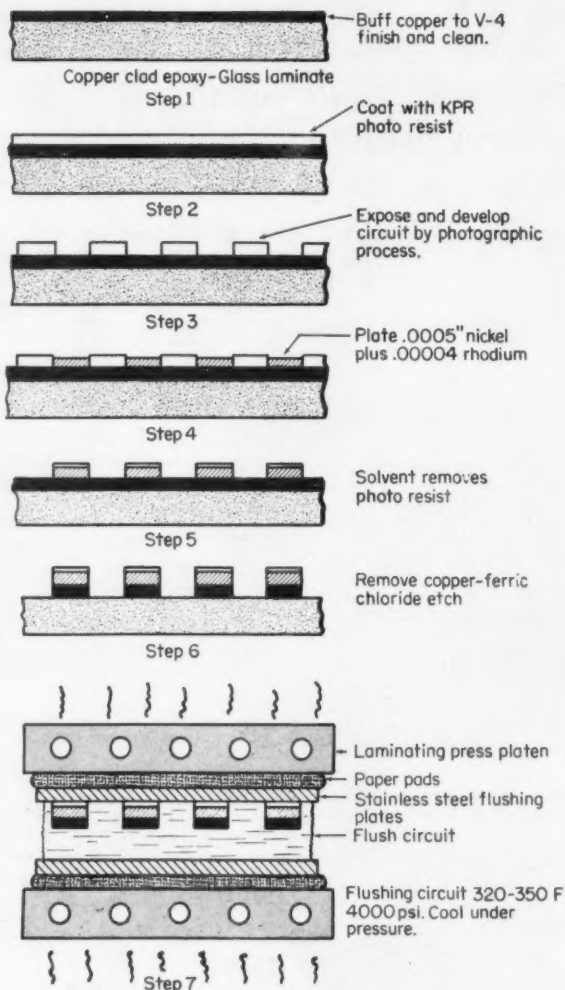


Fig. 3—Operations in the direct etching process.

It is difficult to maintain flushness within 0.0001 to 0.0002 in. due to the inherent problems of controlling the depth of etch, Step 3, and the thickness of nickel plate, Step 4.

The Direct Etching Process: Operations are shown in Fig. 3. The basic material is a copper-clad G-10 Epoxy glass laminate with a high epoxy resin surface ply. In Step 3, photographic methods are recommended for most accurate line definition. Step 7, the flushing operation, takes 10 to 30 minutes.

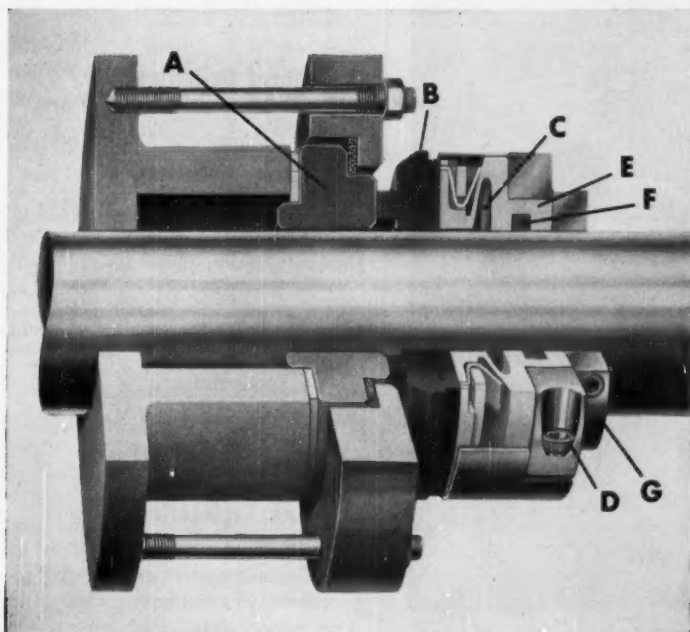
It is possible to consistently produce circuits with the conductors flush within 0.0001 in. Surface finish on the rhodium can be maintained in a range of V-2 to V-4. Line definition can be held within 0.005 in.

Resulting circuits will withstand



MECHANICAL SEALS

in Design
Engineering



LAST LONGER IN CORROSIVE CHEMICALS

Garlock CHEMISEAL® Mechanical Seals have, through years of application, proved their ability to seal effectively against all chemicals . . . from the "easier" Methanol, Acetic and Propionic Acids to the more reactive Hydroxyacetic, Sulfuric, Adipic Acids and Hydrocarbon Slurry.

High-quality construction. The bellows unit of CHEMISEAL Mechanical Seals is, in all cases, made of chemically-inert Teflon†. Various materials are used for the sealing faces dependent upon the medium and service requirements. Referring to the illustration at left, the seal comprises a stationary face "A" secured to the stuffing box and a rotary face "B" which rotates with the balance of the seal mechanism and is secured to the shaft. Between these precision lapped faces a leak proof seal is accomplished by the spring loaded Teflon bellows section "C." Clamp "D" secures area "E" to the shaft with the help of the Hypalon or Teflon O-Ring "F," forming a drop-tight seal. Back-up collar "G" is an added precaution to prevent the seal from working out on the shaft.

There are other benefits, too, that CHEMISEAL Mechanical Seals can add to your particular application. Consider the fact that they offer a life expectancy many times that of other seals . . . don't score the shaft during operation . . . are easy to handle and install.

Solve your difficult sealing problems. Apply Garlock CHEMISEAL Mechanical Seals against all media—including solids in suspension—in pressures to 100 psi at 75°C, or 75 psi at 100°C. Standard sizes to fit all pump shafts from 1/8" to 2 1/8"; special sizes also available. Discuss complete details with your local Garlock representative, or write for Catalog AD-164. The Garlock Packing Company, Palmyra, New York.

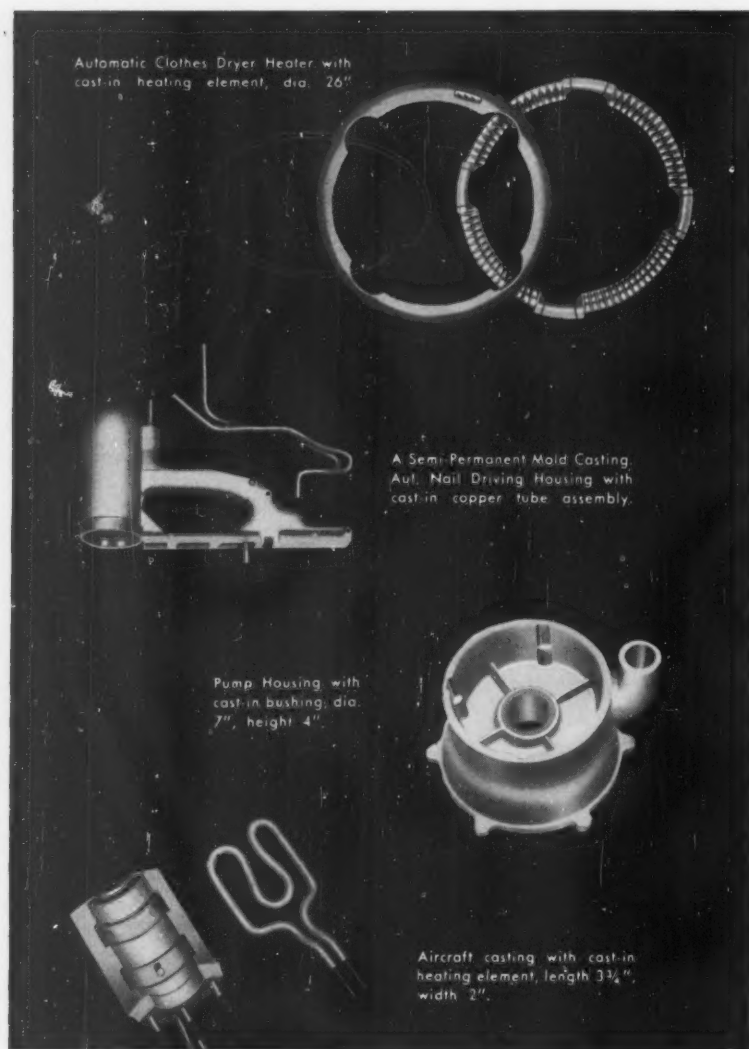
GARLOCK

Canadian Div.: The Garlock Packing Company of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded & Extruded Rubber, Plastic Products

*Registered Trademark
†DuPont Trademark for TFE Fluorocarbon Resin



Automatic Clothes Dryer Heater with cast-in heating element, dia. 26"

A Semi-Permanent Mold Casting, Aut. Nail Driving Housing with cast-in copper tube assembly.

Pump Housing with cast-in bushing, dia. 7", height 4"

Aircraft casting with cast-in heating element, length 3 3/4", width 2"

COMBINATION PERFORMANCES "HARNESSED" WITH ALUMINUM PERMANENT MOLD casting

Your product design requirements may dictate a light weight, rust-proof casting, tailored to perform with a heating element, bushing or insert. ALUMINUM PERMANENT MOLD casting is the answer, as it is superior to other casting methods for holding and positioning metals selected for integral performances.

Shown here are examples of ALUMINUM PERMANENT MOLD CASTINGS already in use. All requiring the physical advantages of aluminum with bearing metals to resist frictional wear, and conductive metals for varied wattage loads. At EXALCO these are common

requirements and create no production challenge to our skilled permanent mold casting engineers.

Your "finished product appearance" may be of primary importance. Our DURAGLAZE was developed by us to provide a finish that cannot crack or chip. It is mechanically applied to any flat or contour surface and assures greater durability than chemical and electrochemical finishes.

Feel free to write us for production procedure and estimates of aluminum castings with or without cast-in features.



Exalco MANUFACTURING CO.
ALUMINUM IN PERMANENT MOLD AND SAND

44 SHELDON ROAD • BEREA, OHIO • BEREA 4-2091

DESIGN ABSTRACTS

many millions of operations under wiping contact conditions. A certain emitter, for example, utilizes a 0.010-in. diameter wire follower under 4 g loading and has been tested to 60 million operations without excessive wear on either wiper or circuit.

"Flush Printed Circuitry—A Survey of Three Processes," *SPECTATOR*, Western New England Section, Society of Plastics Engineers, Vol. 1, No. 2, October, 1959, pp. 30 to 36.

electrical

Proposed Definitions for Semiconductor Rectifier Parts

AIEE Semiconductor Metallic Rectifier Committee

Review of and revisions to AIEE Publication No. 59. Pictures and sketches supplement the text. Discussion and comments are solicited.

AIEE Paper No. 59-1200, "Proposed Definitions for Semiconductor Rectifier Components and Equipments," presented at the AIEE Fall General Meeting, Chicago, October, 1959, 26 pp.

management

Design and Development Of an Engineering Report

George B. Goodall, Ampex Corp.

An approach to the engineering report from an engineering viewpoint. This paper shows that an orderly and logical presentation of material is more important than skillful writing techniques. It relates the organization of the report to a simple engineering problem. It explains why the engineer should originate the reports on his own project, and the growth in professional stature that will result.

AES Paper No. 132 "Design and Development of An Engineering Report," presented at the 11th Annual Meeting, New York, October, 1959, 9 pp.

materials

Effects of High Temperatures On Magnet Core Materials

Michael Pasnak and Richard Lundsten
U. S. Naval Ordnance Laboratory

An experimental study of the effects of temperature on the magnetic properties of ferromagnetic alloys. The materials were evalu-

ated after several temperature cycles between 24 C and 500 C. Results indicate that, in general, high temperature decreased the maximum induction and the residual induction from their 24 C values. For all materials except two, the coercive force decreased with increase in temperature. Maximum permeability increased with increasing temperature until the Curie temperature was approached, then it started to decrease. Initial permeability also increased with increasing temperature, but unlike maximum permeability, it started to decrease at a greater rate and at a lower temperature. Grain-oriented materials were more affected by temperature cycling than were unoriented materials.

AIEE Paper No. 59-117, "Effects of Ultra High Temperature on Magnetic Properties of Core Materials," presented at the AIEE Fall General Meeting, Chicago, October, 1959, 8 pp.

processes

Theory and Application of Electrical-Discharge Machining

George G. Bott, Process Engineer,
Grumman Aircraft Engineering Corp.

Underlying principles of this basic mechanism of metal removal; effects of an electrical-discharge-machined surface on the mechanical and chemical properties of the workpiece material. Perhaps the most controversial issue is whether sufficient heat is generated at the workpiece surface to cause melting. Experiments conducted on stainless steels indicate that high or melting temperatures were not generated during the machining operation. On titanium, there were no indications of melting even though a structural change did take place. It is believed that the heat generated on the workpiece surface was caused by titanium's low thermal conductivity.

The results of a series of tensile and hardness tests indicate that these properties had no effect on the amount of metal removed.

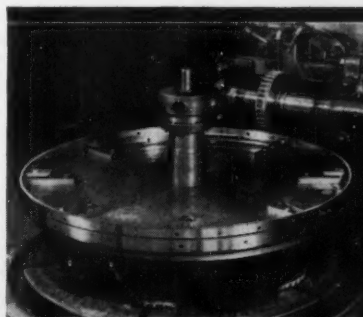
One of the advantages of EDM is that complex shapes and configurations can be reproduced, providing that a suitably shaped electrode can be made and brought into the proximity of the workpiece. Using the electroless nickel plating

whatever your Gear Problem... it will pay you to bring it to us

• BRAD FOOTE has the finest cutting and shaping equipment available for producing the widest possible variety of precision gears.

• Our heat-treating facilities are second to none. From blanks to the finished precision gears...BRAD FOOTE takes the job all the way. There is no division of responsibility.

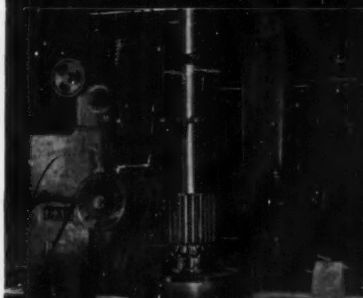
• Whatever your gear-cutting needs...racks, speed reducers, transmissions or intricate power units...BRAD FOOTE fills all your requirements from one source. Let our engineers consult on your requirements. There is no obligation. It may save you time and money.



Medium-sized hobbing machine cutting teeth in special crown gears



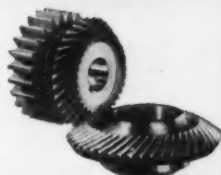
Special precision 154" gear shaper cutting internal gear for use in large wind tunnel



Large hobbing machine cutting teeth of large pinion on 12 foot shaft



Large special 154" gear shaper cutting large spur internal ring gear for radar equipment



**BRAD FOOTE
GEAR WORKS, INC.**

1311 South Cicero Avenue • Cicero 50, Illinois
Bishop 2-1070 • Olympic 2-7700



subsidiary • PITTSBURGH GEAR COMPANY, Neville Island • Pittsburgh 25, Pa., Phone: SPoulding 1-4600

put **HEINZE** in your designs

POWER

in
compact
size...



HEINZE UNIVERSAL MOTORS

When you want power in compact series motors, Heinze Universal Motors provide high starting torque, variable speed, reversibility and high output. Originally developed for sewing machines and office machines, they are extremely flexible in design for a variety of uses not requiring constant speed. Flat sided models are especially adaptable for limited space.

Horsepower ratings are from 1/10 to 1/30. Load speed is 7,500 rpm. Standard voltage rating is 115V, AC/DC but motors are supplied for other voltages in AC or DC. Rotation is CW, CCW, or reversing. Optional mounting arrangements include tapped holes on flat side.

Send coupon for new catalog on Heinze Universal Motors — plus the complete line of Heinze sub-fractional horsepower motors and blowers.

HEINZE ELECTRIC COMPANY
685 Lawrence St.
Lowell, Massachusetts

Heinze Electric Company
Dep't D, 685 Lawrence Street
Lowell, Massachusetts

Please send new catalog on Heinze sub-fractional motors and blowers.

Name & Title.....
Company.....
Street & No.....
City & State.....

Circle 492 on Page 19

DESIGN ABSTRACTS

process to provide the base metal, subsequent electrode materials, such as brass and copper, have been successfully plated or sprayed on wooden electrodes.

ASTE Paper No. 220, Vol. 59, Book 2, "Recent Developments in the Theory and Application of Electrical-Discharge Machining," presented at the 27th Semiannual Meeting, St. Louis, October, 1959, 21 pp.

techniques

Reliability versus Cost In Electronic Design

N. L. Kreuder, Burroughs Corp.

Ways to reconcile reliability and cost in the selection of circuitry and components. The engineer is often forced to choose between two design philosophies:

1. Every part will be used conservatively, even if this increases the total part count. The light duty will be depended upon to keep up the reliability.
2. The part count will be kept down even if some of the parts have to work hard. The low part count will be depended upon to keep up the reliability.

Successful equipment has been designed using each of these design philosophies, but intuition suggests there may be an optimum compromise between them. The analysis in this paper shows that an optimum does exist, and a method is described for finding this optimum.

IRE paper, "Electronic Design: Reliability Versus Manufacturing Cost," presented at the Western Electronic Show and Convention (WESCON), San Francisco, August, 1959, and published in 1959 IRE WESCON Convention Record, Part 6, pp. 19-22.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

AES—Audio Engineering Society, P.O. Box 12, Old Chelsea Station, New York 11, N. Y.

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.

ASTE—American Society of Tool Engineers, 10700 Puritan Ave., Detroit 38, Mich.

IRE—The Institute of Radio Engineers, 1 East 79th St., New York 21, N. Y.

SPEctator Editorial Office, Somers, Conn.



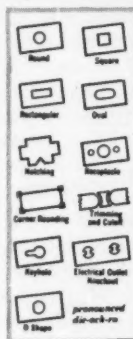
ACCURACY ASSURED

WITH DI-ACRO
PRECISION PUNCHES
AND DIES

Immediate Delivery from factory stock

Accurate hole location is easily achieved with Di-Acro Precision Punch and Die sets because the centering point on the punch is ground concentric to the cutting edges, there is no "slop" even when several holes are punched in a blank. Hole sizes are accurate due both to the high degree of concentricity of the punch and die set and the choice of clearance which allows you to obtain clean, burr free holes no matter what material thickness is to be perforated. All Di-Acro punches and dies are precision made of high quality tool steel.

Over 500 standard sizes of Di-Acro Precision Punches and Dies in 12 standard styles are stocked. Punch Adapters and Die Holders are available to fit all styles of punch presses.



Consult the Yellow Pages of your phonebook under Machinery—Machine Tools for the name of your Di-Acro distributor or write us for catalog and price list.

di-acro
PRECISION
METALWORKING
EQUIPMENT

**O'NEIL-IRWIN
MFG. CO.**

416 Eighth Avenue
Lake City, Minnesota

AEROQUIP CAN ASSIST YOU AT ALL PHASES OF MANUFACTURE

- DESIGN
- PROTOTYPE
- PRODUCTION
- FIELD SERVICE
- SERVICE PARTS

You Can Get Specialized Types of Aeroquip Single Wire Braid Hose For Any Application



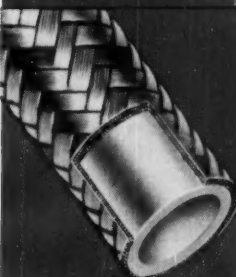
1503 HOSE

for hydraulics, air, gasoline, crude, fuel and lube oils, hot water systems; for pressures up to 3000 psi., depending on size; temperature range -40° F. to +275° F.; in 1/4" to 2 1/2" O.D. tube sizes.



2651 AND 2652 HOSE

for hydraulics, gasoline, crude, fuel and lube oils, air and water systems; abrasion-resistant rubber cover; temperature range -40° F. to +250° F.; for pressures up to 3000 psi., depending on size; in 1/4" to 3" O.D. tube sizes.



2802 HOSE OF TEFLON

with patented "super gem" Reusable Fittings for heavy-duty steam, chemical, air compressor discharge lines; temperature range -100° F. to +500° F.; for pressures up to 1500 psi. (200 lbs. steam); 1/4" to 1 1/4" O.D. tube sizes.



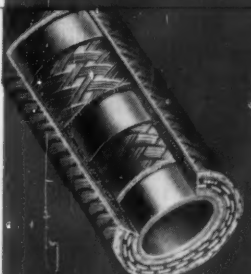
1532 HOSE

for phosphate-ester base hydraulic systems up to 3000 psi., depending on size; also suitable for anhydrous ammonia applications; temperature range -40° F. to +275° F.; in 1/4" to 2" O.D. tube sizes.



2601 LIGHTWEIGHT HOSE

for engine fuel and lube systems; withstands temperatures up to +300° F., vibration and pressures encountered in heavy-duty engine operation. Available in 1/4" to 2" O.D. tube sizes.



1533 HOSE

for LP-Gas applications; designed to provide contact points for safe conductivity of static electricity; listed by Underwriters' Laboratories for all engine and fixed installations; in 1/4" to 1" O.D. tube sizes.

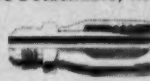
All Aeroquip Hose Fittings Are Detachable, Reusable



split flange fittings



S.A.E., J.I.C. & P.T.T. swivel nut fittings



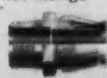
S.A.E. & J.I.C. male flare fittings



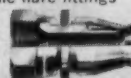
S.A.E. & J.I.C. swivel elbow fittings



male pipe fittings



"super gem" (Teflon) male pipe fittings



"super gem" (Teflon) J.I.C. swivel nut fittings



S.A.E. & J.I.C. swivel nut fittings



AEROQUIP CORPORATION, JACKSON, MICHIGAN

INDUSTRIAL DIVISION, VAN WERT, OHIO • WESTERN DIVISION, BURBANK, CALIFORNIA
AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO

AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

"super gem" is an Aeroquip trademark.
Teflon is DuPont's trademark for its tetrafluoroethylene resin.
*U.S. Patent Nos. 2,833,567 and 2,731,279.

Aeroquip Corporation, Jackson, Michigan
Please send me complete information on Aeroquip Single Wire Braid Hose.

Name _____
Title _____
Company _____
Address _____
City _____ Zone _____ State _____

Helpful Literature for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Pushbutton Switches

One-shot pushbutton switch assemblies that have a special circuit to produce one square wave pulse regardless of operating speed are detailed in Data Sheet 150b. Pulse widths range from 0.1 to 10 microseconds. Application data and circuit diagrams are included. 8 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 601 on Page 19

PNP Phototransistors

High speed response and high sensitivity are combined in line of PNP germanium alloy junction phototransistors, subject of Brochure G-190. Ratings, cutoff and small signal characteristics, mechanical data, light sensitivity, photo spectral response, and other factors are covered. 8 pages. General Transistor Corp., 91-27 138th Place, Jamaica 35, N. Y. D

Circle 602 on Page 19

Power Connectors

Closed ring entry design contacts contribute to reliability of Series 190 miniature power connectors with center screw-lock. Described in Bulletin 1900, they have 152, 104, 78, and 34 contacts and various wire terminations. 6 pages. DeJura-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 603 on Page 19

Coolant Pumps

Informative Catalog 59A descriptively covers Gusher machine tool coolant pumps available in sizes from 1/10 through 7 1/2 hp. Dimensions and capacities and performance curves of immersed, long immersed, and pipe connected types in capacities to 400 gpm are featured. 16 pages. Ruthman Machinery Co., 1809 Reading Rd., Cincinnati 2, Ohio. G

Circle 604 on Page 19

Static Switching

An advance method of static control through the use of solid state power/logic switching systems is detailed in Bulletin S-881A. Described is the Stat-Pack magnetic amplifier which performs digital computation, switching, and power amplification in a single operation. 6 pages. Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y. D

Circle 605 on Page 19

Aluminum Joining

Where and how to use aluminum for welding, brazing, and soldering is subject of a series of charts. Tensile strength, recommended joining materials, per cent elongation, and typical uses are shown for 24 aluminum alloys. 2 pages. All-

State Welding Alloys Co., 249-55 Ferris Ave., White Plains, N. Y. D

Circle 606 on Page 19

Pipe Fittings

The applications and benefits of fish-mouth weld type, branch connection, pipe fittings are pictured and described in illustrated booklet. Cost comparisons, engineering design data, points of practical use, and advantages of these fittings are covered. 16 pages. H. K. Porter Co., Forge & Fittings Div., Roselle, N. J. D

Circle 607 on Page 19

Electric Motors

Chemical constructed, explosionproof, and totally enclosed electric motors in 1/12 through 250 hp ratings are described as to principal features in Brochure SB-185-859. Frame sizes range from 56 through 680. 8 pages. Marathon Electric Mfg. Co., Wausau, Wis. K

Circle 608 on Page 19

Carbide Hard Facing

Properties and application techniques for hard facing products with Metco tungsten carbide ThermoSpray powders and an easily maneuvered ThermoSpray gun are explained in Bulletin 139. Gun uses only oxygen and acetylene. 4 pages. Metallizing Engineering Co., Westbury, L. I., N. Y. D

Circle 609 on Page 19

Pneumatic Calibrator

Used for checking pneumatic controls and instruments in the 3 to 15-psi range, Series A-755 pneumatic calibrator is subject of Bulletin TP-44-A. It has accuracy of 1 part in 1000, full-scale range. 4 pages. Wallace & Tiernan Inc., 25 Main St., Belleville 9, N. J. J

Circle 610 on Page 19

Plastic Components

"Good Plastics Design . . . Makes Cents" is title of booklet which covers such factors as taper, wall thickness, threads, parting lines, inserts, and holes which must be considered in designing plastic parts. Illustrations stress good and bad practices. 12 pages. American Insulator Corp., New Freedom, Pa. E

Circle 611 on Page 19

Power Supplies

Prices are included in information presented in Data Sheet 100A on standard and special types of power supplies. Featured check list enables designers to get specific information. 2 pages. Burmac Electronics Co., 142 S. Long Beach Rd., Rockville Centre, N. Y. D

Circle 612 on Page 19

Chemical Pumps

Pulsafeeder automatic metering chemical pumps for handling and proportioning corrosive and noncorrosive fluids are described in Bulletin 530. Tables on sizes, capacities, and performance aid in engineering. Capacities range to 339 gph and pressures to 3200 psi. 4 pages. Lapp Insulator Co., Process Equipment Div., 111 Hall St., LeRoy, N. Y. N

Circle 613 on Page 19

Power Transistor Pairs

Line of NPN-PNP germanium power transistor pairs in industrial packages for up to 100 v is used in push-pull Class B circuits. They are hermetically sealed in welded TO-10 male and TO-13 female packages. Design data are provided in Bulletin E-360, 2 pages. CBS Electronics, 900 Chelmsford St., Lowell, Mass. B

Circle 614 on Page 19

Potentiometers

Standard resistance ratings, specifications, and dimensions relative to Model 235 Trimpot humidityproof Resistor carbon potentiometer are provided in Bulletin 235. Resistance values range from 1 K to 10 megs. 2 pages. Bourns, Inc., Trimpot Div., Box 2112, Riverside, Calif. L

Circle 615 on Page 19

Rotary Solenoids

Folder on rotary solenoids describes a complete line of standard and special solenoids, packaged switch assemblies, and 360-degree drive stepping units. Torques to 70 lb-in. can be obtained from units only 1 1/8 in. in diameter and 3 1/2 in. long. 4 pages. Illinois Tool Works, Pacsol Div., 3155 El Segundo Blvd., Hawthorne, Calif. L

Circle 616 on Page 19

Electric Motors

Both alternating and direct current types of fractional horsepower standard and special torque motors are cataloged in Bulletin 208A. Speed-torque curves aid in applying these motors to design needs. Ounce-Inch ratings are given for various percentages of locked service. 4 pages. Ohio Electric Mfg. Co., 5400 Dunham Rd., Maple Heights, Ohio. G

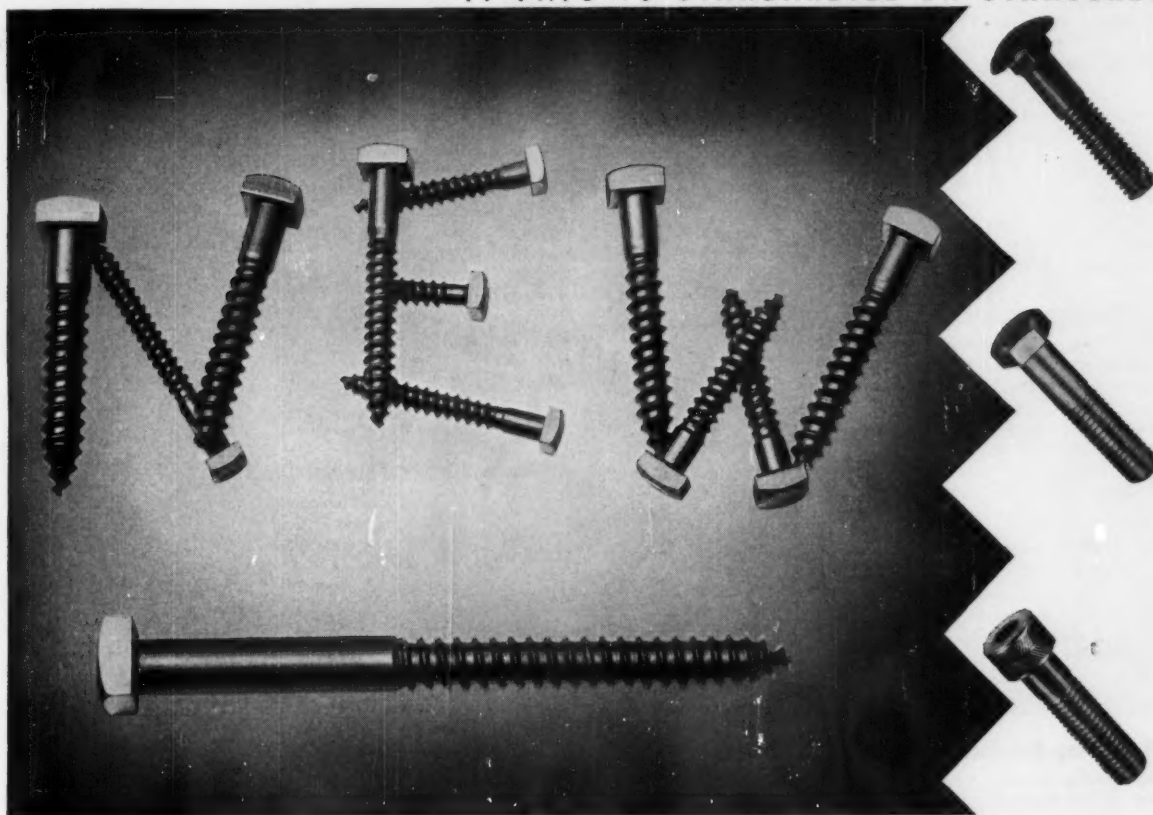
Circle 617 on Page 19

Silicone Rubber

Publication CDS-208 lists outstanding insulated properties of G-E Class 900 electrical grade silicone rubber and discusses major cable insulating applications. It is compared with butyl, GR-S, and natural rubber. 4 pages. General Electric Co., Watertown, N. Y. C

Circle 618 on Page 19

IT PAYS TO STANDARDIZE ON STANSCREW



Lag Bolts Expand Stanscrew Line To Over 5,500 Different Fasteners

Hex machine bolts . . . carriage bolts . . . and now, a broad selection of lag bolts . . . all quickly available from Stanscrew.

These new gimlet point lag bolts, all with full-sized shanks, conform to ASA Standards and are produced to Stanscrew's rigid criteria of fastener quality. Almost 100 sizes are offered as stock items.

With lag bolts, the Stanscrew line now covers more than 5,500 standard catalogued fasteners . . . carefully developed to answer the overwhelming majority of American industrial needs. Included are socket, set, and cap screws . . . nuts . . . dowel and taper pins . . . pipe plugs . . .

studs . . . and, of course, Stanscrew's complete bolt series.

Each of these 5,500 fasteners is always in stock at three conveniently located plants. A rigidly enforced Stanscrew policy assures regular orders are shipped within 24 hours. This means your Stanscrew distributor can provide especially fast service on all occasions . . . and be particularly helpful in emergencies.

Your Stanscrew distributor will also be happy to arrange a visit from the Stanscrew fastener specialist. His recommendations on your assembly procedures can often result in significant savings. Why not call your Stanscrew distributor today?



STANSCREW FASTENERS

CHICAGO | THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS

HMS | HARTFORD MACHINE SCREW COMPANY, HARTFORD, CONNECTICUT

WESTERN | THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

STANDARD SCREW COMPANY 2701 Washington Boulevard, Bellwood, Illinois

Wire Wound Resistors

Strain-free design has been accomplished in Bobbinless precision wire wound resistors by eliminating the bobbin and floating the resistive element in a viscous fluid. Resistors are made in power ratings to 1/2 w. Design and performance details are given in Brochure GR-30. 8 pages. General Transistor Corp., 91-27 138th Place, Jamaica 35, N. Y. D

Circle 619 on Page 19

Two-Circuit Switches

Data Sheet 164 details the 3MN Series of precision two-circuit switches for machine tool limit and control uses. These snap-action switches are offered in single-pole double-break contacts and rated 15 amp at 120, 240, 480, or 600 v ac. 2 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 620 on Page 19

Pipe Branch Connections

Catalog TF-1-59 illustrates the new Tee-Lets and Fishmouth connection fittings for pipe branching. Fittings range in branch sizes from 1/8 to 12 in. and are machined from solid steel bars. 6 pages. H. K. Porter Co., Forge & Fittings Div., Box 95, Roselle, N. J. D

Circle 621 on Page 19

Ball Bearing Retainers

Ball bearing retainer specifications tabulated in brochure cover cup and cone, single piece thrust, metric thrust, ribbon, and deep groove retainers. 12 pages. National Bearings Co., Lancaster, Pa. E

Circle 622 on Page 19

Screw Thread Form

Through use of photoelastic studies, Folder 2577 depicts the change to the new thread form of Unbrako Hi-Life socket head cap screws. Fatigue life is reportedly up to 100 per cent greater. 4 pages. Standard Pressed Steel Co., Jenkintown, Pa. C

Circle 623 on Page 19

Copper Base Alloys

"What is AMPCO" is title of unusual Bulletin G-39 describing products and plant facilities of this manufacturer of copper base alloys in the form of solid rounds, cast bars, sheet and plate, die blanks, and guide pin bushings. 10 pages. AMPCO Metal, Inc., Milwaukee 46, Wis. K

Circle 624 on Page 19

Teflon Coatings & Finishes

Properties and successful applications for Teflon coating of metal and ceramic tools and parts are described in folder. Coating contributes antisticking or chemically resistant properties. 4 pages. Cadillac Plastic & Chemical Co., 15111 Second Ave., Detroit 3, Mich. H

Circle 625 on Page 19

Threaded Fasteners

Available literature includes Form 600A on the Camcar Cold-Flow technique of metal forming high strength parts and fasteners and a bulletin and "Thread-Cutting Fasteners." Types for cutting

threads in metal, castings, plastics, and sheet metal and plywood are covered. Selection guide is featured. 8 pages each. Camcar Screw & Mfg. Co., Rockford, Ill.

Circle 626 on Page 19

AC Test Sets

Console type high voltage alternating current test sets rated 20,000 to 50,000 v, 2 kva capacity, for dielectric testing of insulation, components, oil linemen's gloves and apparatus up to 50 kv are subject of Bulletin GEA-6839. Data cover both mobile and stationary units. 4 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 627 on Page 19

Preventing Metal Corrosion

CRC 3-36 liquid prevents corrosion of bare, plated, or painted iron, steel, aluminum, copper, brass, magnesium, and other common metals. Folder explains how formula works, how it is applied, its duration of effectiveness, and physical specifications. 8 pages. Corrosion Reaction Consultants, Inc., 116 Chestnut St., Philadelphia 6, Pa. E

Circle 628 on Page 19

Polyester Molding Compounds

Price and quantity discount schedule for ThermoFlow reinforced polyester molding compounds is now available. Atlas Powder Co., Chemicals Div., Wilmington 99, Del. C

Circle 629 on Page 19

Steel Analyses Guide

"Pocket Guide to Steel Analyses" lists compositions of 40 stainless steels, 184 alloy steels, and 105 carbon steels most often used in industry. Specs are listed with corresponding SAE, AISI, and AMS numbers. 20 pages. Jones & Laughlin Corp., Stainless & Strip Div., Box 4606, Detroit 34, Mich. H

Circle 630 on Page 19

Circuit Breaker

Special purpose Type ALB-1C circuit breaker described in publication GEA-6759 is rated 5-75 amp at 300 v ac, 125 v dc. Dimensional and ordering information are included. 2 pages. General Electric Co., Circuit Protective Devices Dept., 90 Whiting St., Plainville, Conn. B

Circle 631 on Page 19

Curtain & Cover Materials

Curtain and cover materials described in Bulletin GS-400 include neoprene-base, Teflon and silicon types with temperature ranges of 100 to 500° F. 2 pages. A&A Mfg. Co., 712 S. 12th St., Milwaukee 4, Wis. K

Circle 632 on Page 19

Soldering Supplies

Soldering supplies shown in Catalog C-1 include soldering fluids, stainless steel fluxes and solder, Flux-N-Solder, soldering salts and metal cleaner, special Alumaweld solders, solder and flux kits, soldering pastes, tinning compounds, and other accessories. 10 pages. Johnson Mfg. Co., Mt. Vernon, Iowa. I

Circle 633 on Page 19

Spray Nozzles

Nozzles for industrial high-pressure spray applications such as insulating, washing, and coating are subject of Bulletin L-844B. Various designs, spray patterns, dimensions, and capacities are tabulated. 8 pages. Food Machinery & Chemical Corp., John Bean Div., Lansing 4, Mich. H

Circle 634 on Page 19

Recorder Timers

Standard models of recorder timers with chart drives for up to 360 hours are covered descriptively in illustrated bulletin. Service offered by company to custom engineer and produce timing mechanisms is described. Also shown are appliance timers of various types. 4 pages. Lux Mfg. Co., Waterbury, Conn. B

Circle 635 on Page 19

Thermal Discs

"The Story of the Spencer Disc" describes the origin and operation of this snap-acting, disc type, thermal element. It is used to actuate Klaxon thermostats, circuit breakers, and inherent overheat protectors. Also detailed are other controls such as starting relays, precision switches, and thermal valves. 29 pages. Texas Instruments Inc., Metals & Controls Div., 34 Forest St., Attleboro, Mass. B

Circle 636 on Page 19

Infrared Materials

Report No. 4 in a series of progress reports is entitled, "Glasses for Infrared Refractive Systems." It describes three types of glass which have been developed for these systems. This and future reports will be sent upon request. Bausch & Lomb Optical Co., Military Sales Dept., Rochester 2, N. Y. N

Circle 637 on Page 19

Office Copying Machines

Convenient slide rule comparator lists prices and comparative performances of office copying machines made by ten different manufacturers. Simple setting of slide determines such factors as machine and paper costs, types of copying processes, number of copies possible per minute, and number of processing steps required. Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn. J

Circle 638 on Page 19

Hydraulic Filters

Usable on the pressure or suction side of the pump in hydraulic systems rated to 150 psi, the Arrow In-Line filter has a porous sintered metal element for 51 to 123-micron filtration or a wire cloth element for 125-micron filtration. Full specifications are given in Bulletin IL-F605. 2 pages. Arrow Tools, Inc., 1900 S. Kostner Ave., Chicago 23, Ill. J

Circle 639 on Page 19

Carbide Cutting Tools

Examples of many regular and special carbide cutting tools are shown in file folder available for ready reference filing. Cole Carbide Industries, Box 49, Royal Oak, Mich. H

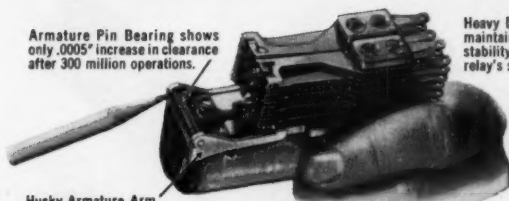
Circle 640 on Page 19



**"THIS RELAY
WILL GIVE US
300 MILLION
OPERATIONS, JOE"**

HERE'S WHY P&B TELEPHONE TYPE RELAYS GIVE YOU **reliable performance over long life**

Armature Pin Bearing shows only .0005" increase in clearance after 300 million operations.



Husky Armature Arm prevents sagging or bending.

BS SERIES TELEPHONE TYPE

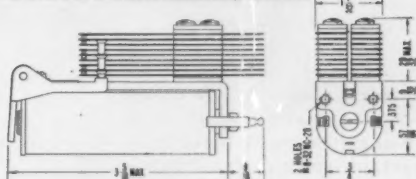
Measure the thickness of the BS series armature arm. You will find the cross section area is greater than ordinary relays of this type. Here is the kind of quality that spells dependability.

Observe that the stainless steel hinge pin runs the full width (not just half) of the armature, providing optimum bearing surface. This pin, operating in a stainless steel sleeve, shows only minimal wear during nearly a *third of a billion operations*.

Best of all, P&B quality costs no more. A whole new plant is being devoted to the production of high performance telephone type relays. Your nearest P&B sales engineer will be happy to discuss your relay problems. Call him today.

Heavy Duty Frame maintains dimensional stability, adds to relay's sensitivity.

BS SERIES ENGINEERING DATA



GENERAL:

Breakdown Voltage: 1000 volts rms 60 cy. min.

Ambient Temperature: -55° to +85° C.

+125° C available on special order.

Weight: 9 to 16 ozs.

Terminals: Pierced solder lugs;

Coil: One #16 AWG wire

Contacts: Two #18 AWG wires

Enclosures: Dust covered or sealed

CONTACTS:

Arrangements: DC—up to 28 springs

AC—up to 24 springs

Material: 1/4" dia. twin palladium.

Up to 1/4" dia. single silver.

Other materials on special order.

Load: 4 amps at 115 volts, 60 cycle resistive

Pressure: 15 grams minimum

COILS:

Resistance: 100,000 ohms maximum

Current: 10 amps maximum

Power: DC—50 milliwatts per movable arm.

Greater sensitivity on special order.

AC—17.9 volt-amps.

Duty: Continuous

Treatment: Centrifugal impregnation

Voltages: DC—up to 300 volts with series resistor. AC—up to 250 volts, 60 cy.

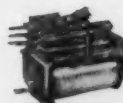
MOUNTING:

Two #8-32 tapped holes 1/4" o.c.

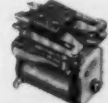
Other mountings on special order.



GS SERIES—Excellent sensitivity: 50 mw per movable arm minimum (DC). For applications requiring many switching elements in small space.



LS SERIES—Medium coil relay with short springs and light weight armature for fast action, reliability and long life.



TS SERIES—Short coil relay is available in AC and DC versions. Long life construction. Can be supplied (DC) with up to 20 springs (10 per stack).

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR



POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO



Eastman 910 Adhesive solves another production bottleneck

The Rhine Craft Corporation, of Brooklyn, N. Y., introduced recently a line of costume watch jewelry...pendants, pinfarms and bracelets.

Key to low manufacturing costs was a fast, simple method of mounting the watch case to the jewelry base. Soldering proved too slow and costly.

The answer was found in quick-setting, high-strength Eastman 910 Adhesive.

The adhesive is applied to the jewelry base and the watch case is set in place. *Within minutes, a permanent bond is formed.* The bond is so strong the gold-plating separates from the watch case when it is forced out of the jewelry base.

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is simple to use. No mixing, heat or pressure is required. Upon spreading into a thin film between two surfaces, setting begins immediately. With most materials, strong bonds are made in minutes.

What production or design problem can this unique adhesive solve for you?



Bonds Almost Instantly
...Without Heat,
Pressure or Catalyst

For a trial quantity (1/3-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9101 Dean Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. M-1, Kingsport, Tenn. (Not for drug use)

Circle 497 on Page 19

HELPFUL LITERATURE

Industrial Crystals

Industrial Crystal Bulletin F-815 is a treatise on the growth of single crystals of incongruently melting yttrium garnet by the flame fusion process. How slow linear growth rates in the order of 0.1 in. per hr were obtained in a modified Verneuil furnace is described. 12 pages. Linde Co., 30 E. 42nd St., New York 17, N. Y. C

Circle 641 on Page 19

Blind Rivets

Pressure-tight up to 500 psi, new closed-end Pop rivets are available in 1/4, 5/32, and 3/16-in. diameters. They seal as they are set from one side of the material. Details of these fasteners and applications tools are given in folder. 2 pages. United Shoe Machinery Corp., Pop Rivet Div., Shelton, Conn. B

Circle 642 on Page 19

Corrosion Inhibitor

CRC 2-26 is a liquid formula that displaces and seals out water and moisture, protects metal surfaces against corrosion, and lubricates. It was developed for use in electrical and electronic equipment. How and where it is used is explained in illustrated bulletin. 6 pages. Corrosion Reaction Consultants, Inc., 116 Chestnut St., Philadelphia 6, Pa. E

Circle 643 on Page 19

Alloy Tubing & Pipe

Applications of Hastelloy Alloys B and C tubing and pipe in services involving acids and other corrosive fluids are discussed in Bulletin TD 117A. Comparative resistances to various corrosive media, physical and mechanical properties of the alloys, and available sizes of pipe and tubing are detailed. 6 pages. Carpenter Steel Co., Alloy Tube Div., Union, N. J. D

Circle 644 on Page 19

Fusible Terminal Blocks

Fusible terminal blocks and assemblies for 25 and 50-amp service are described and tabulated in Supplementary Price Sheet 9080. Ratings and number of fusible circuits are listed. 2 pages. Square D Co., 4041 N. Richards St., Milwaukee 12, Wis. K

Circle 645 on Page 19

Time Delay Relays

Digital special time delay relays have a digital setting knob and are adjustable in 0.1-sec increments over a range of 0 to 30 sec. They have a chronometrically governed 24 to 29-v dc timing motor. Full details are given in Form 501. 2 pages. A. W. Haydon Co., Waterbury, Conn. B

Circle 646 on Page 19

Pipe Fittings

Tables contained in technical Bulletin FDC-265 catalog size, dimensional, and physical data on line of welding fittings and forged steel flanges in 10-in. nominal pipe sizes. 6 pages. Babcock & Wilcox Co., Tubular Products Dept., Milwaukee 46, Wis. K

Circle 647 on Page 19

for longer life

and
no
oil leakage
**specify NARDA
Piston Accumulators**



FEATURING:

- Self-balancing piston
- Triple "O" ring seal—all three active
- Auto-relieving piston
- End caps provide dashpot action and use same seals as piston, thus requiring only one seal size for spare parts.



FOR:

- Auxiliary power
- Surge dampener
- Emergency power
- Leakage compensator
- Pressure transfer barrier

THREE MOST POPULAR SIZES:

One quart, one-half gallon and one gallon, 13", 18 1/2" and 28 1/2" long, respectively. All 4 1/4" diameter. (Larger sizes: 2 1/2, 5, 10 gallons; all 8 3/4" diameter.)

Standard temperature range: -40° to +200° F. Seals also available for fuels and special fluids as well as for temperatures from -65° to 400° F.

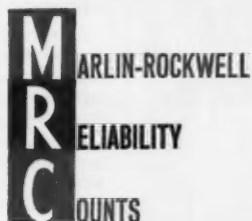
For more information about these new Narda Accumulators, as well as other models now in development, write to us at Dept. MD-2.

Some distributorships in Western and Southern states still open.



Circle 498 on Page 19

IN PILLOW BLOCKS, FLANGE and FLANGETTE UNITS



Pillow Blocks & Flange Units

with MRC **Labri-Seal®** Ball Bearings

MRC Pillow Blocks and Flange Units combine smooth contour and compact design with rugged strength. They are equipped with MRC Labri-Seal Ball Bearings.

The Labri-Seals combine the advantages of a rotating flinger, labyrinth seal and positive contact synthetic rubber seal.

The bearings are lubricated with a high quality, long life grease at assembly — eliminating necessity of further lubrication — resulting in longer life and savings in maintenance cost.

MRC LABRI-SEAL Ball Bearings keep out dirt and moisture and retain the bearing lubricant.

Their efficiency is proven in thousands of successful applications.



MRC Pillow Blocks



MRC Flange Units

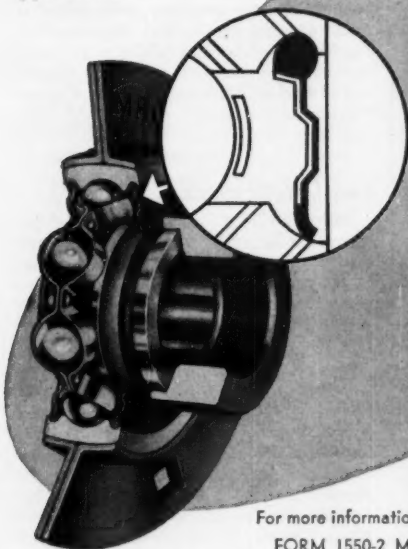
Flangettes

with MRC **Synthe-Seal®** Ball Bearings

The MRC Flangette design provides a high quality — easily installed unit with a versatile mounting arrangement for agricultural and industrial applications.

MRC Flangette Units are complete with MRC Synthe-Seal Ball Bearings with locking collar.

MRC Synthe-Seal Ball Bearings have a long history of successful operation in thousands of applications including extreme conditions of dirt and moisture and where leakage of lubricant might damage products being processed.



MRC Flangette Units

For more information write or phone for:

FORM 1550-2 MRC BALL BEARING PILLOW BLOCKS AND FLANGE UNITS

FORM 1547-2 MRC POWER TRANSMISSION BALL BEARINGS
FORM 1528-13 MRC SYNTH-SEAL® BALL BEARINGS
ENGINEERING NO. 7-17 FLANGETTES

Marlin-Rockwell Corporation
Jamestown, N. Y.



GRC tiny die castings

made in one fast automatic operation
...simple or intricate parts, high in
quality, low in cost

Gries' exclusive patented methods make possible wide design latitude . . . assure uniformity, accuracy and smooth surfaces on small parts of all types . . . for a wide variety of uses . . . at substantial savings. GRC die castings leave the machines trimmed, ready-for-use. In addition GRC's unique single cavity die casting techniques offer new shortcuts in assembly . . . new approaches in product design through our exclusive methods.

Write for fact-filled booklet "Small Zinc Alloy Die Castings," includes helpful designer's check list.



tiny zinc
die castings

NO SIZE TOO SMALL!
Maximum sizes up
to 1 3/4", 1/2 oz.

GRIES

GRIES REPRODUCER CORP.

World's Foremost Producer of Small Die Castings

32 Second St., New Rochelle, N. Y. • NEw Rochelle 3-8600

Circle 500 on Page 19

VIKING LIQUID ABRASIVE PUMPS NOW LAST LONGER

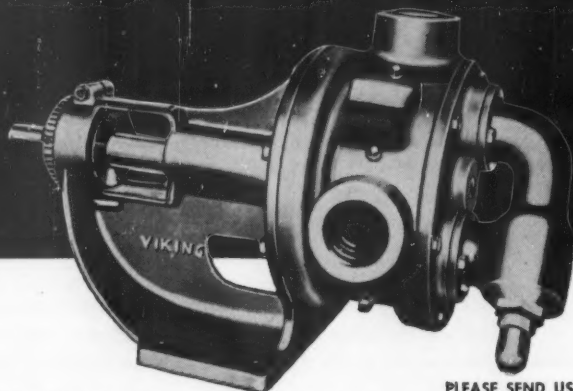


Fig. 64124

Now, you can double or triple pump life with this new heavy-duty Viking. Specially designed with ceramic bearings and mechanical seals to pump paints, inks and other "abrasive liquids. Field tested and proved, pumping liquids from 100 S.S.U. to the heaviest viscous types . . . G.P.M. sizes 3, 6, 12, 16, 25, 40. Let us help you solve your problem.

* Consult factory for recommendations on pumping abrasive liquids other than paints or inks.

PLEASE SEND US THIS INFORMATION:

- Liquid to be pumped
- Viscosity of liquid (S.S.U.)
- Percentage and type of solids present in liquid
- Temperature of liquid
- Specific gravity
- Capacity of pump needed
- Suction lift or head
- Discharge pressure

AND ASK FOR BULLETIN
SP-507H

VIKING PUMP COMPANY

Cedar Falls, Iowa, U.S.A.

In Canada, It's "ROTO-KING" Pumps

See Our Catalog in Sweet's Product Design File

Circle 501 on Page 19

HELPFUL LITERATURE

Conveyor Wheels & Trolleys

Suited for design and engineering reference, illustrated file contains ratings, dimensions, and application data on sealed ball and roller bearing conveyor wheels, hoist trolleys, and rollers. Both standard and special designs of these materials handling equipment components are described. 16 pages. Grey Hub Trolley Wheel Co., 17265 Gable Ave., Detroit 12, Mich.

Circle 648 on Page 19

Permanent Magnet

Alnico VII A is an improved grade of permanent magnet material for core type meters and instruments. Characteristics of oriented and nonoriented forms, as well as demagnetization and energy product curve, are contained in Form 351. 2 pages. Indiana Steel Products Co., Valparaiso, Ind.

Circle 649 on Page 19

Transistors

Series of four bulletins, No. DL-S945, DL-S783, DL-S961, and DL-1006, contains performance and design data on N-P-N diffused junction silicon and grown-diffused silicon tetrode transistors and diffused silicon rectifiers. 6, 4, 4, and 2 pages. Texas Instruments Inc., Semiconductor Components Div., Box 312, Dallas, Texas.

Circle 650 on Page 19

Selective Plating

The Dalic process of selective plating enables one to precision plate selective areas and deposit metals where needed. Equipment and materials for applying common and precious metals by plating are covered in illustrated bulletin. 4 pages. Marlane Development Co., 153 E. 26th St., New York 10, N. Y.

Circle 651 on Page 19

Panel Instruments

Series SC-030 microminiature panel instruments have their specifications given on illustrated catalog sheet. Scale diameter is about 1/2 in. Ranges, resistances, and dimensional drawings are included. 2 pages. Defur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle 652 on Page 19

Flow Indicator

Specification Sheet DS-130-1 describes Sho-Rate Size 8 and 10 Rotameters, low cost units for flow rate indication and alarm signaling. Water and air capacities, ratings, dimensions, and other data are given. 2 pages. Brooks Rotameter Co., Box 432, Lansdale, Pa.

Circle 653 on Page 19

Protecting Drawings

Products developed to aid draftsmen in cleaning and protecting drawings are briefly described in folder. Covered are Draft-Clean powder, Dry-Clean gum eraser pad, and Fixatene fixative. 6 pages. Keuffel & Esser Co., Adams & Third Streets, Hoboken, N. J.

Circle 654 on Page 19

Thermostats

Fixed setting, snap acting Klixon M201 thermostats, subject of Data Sheet MIL-THSN-13, have an over-all diameter of $\frac{3}{8}$ in. Available constructions, electrical ratings, temperature settings, and other data are covered. 2 pages. Texas Instruments, Inc., Metals & Controls Div., Attleboro, Mass. B

Circle 655 on Page 19

Pumps

Series of bulletins detail John Bean inside-packed vertical duplex pumps, inside and outside-packed triplex pumps, and accessories for industrial pumps. Specifications and features of all models are given in the five bulletins. 2 and 4 pages. Food Machinery & Chemical Corp., John Bean Div., Lansing 4, Mich. H

Circle 656 on Page 19

Electric Eyes

Applications for miniaturized electric eyes are counting, sorting, monitoring, assembling, and automatic weighing in various industries. Technical data and specifications, plus application data and schematics and design options are presented. 16 pages. Photomation, Inc., 96 S. Washington Ave., Bergenfield, N. J. D

Circle 657 on Page 19

Potentiometers

Electrical, mechanical, and environmental specifications and drawings of four Helipot single-turn potentiometers are presented for reference in a catalog supplement. Temperature ranges are -65 to 125 and 150° F. Beckman Instruments, Inc., Helipot Div., 2500 Fullerton Rd., Fullerton, Calif. L

Circle 658 on Page 19

Digitizing System

Equipment which converts the position of micrometer lead screw shafts to a digital code which can be punched on a paper tape is subject of illustrated Bulletin 350-6. Its versatility, components, and applications are discussed. 2 pages. Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif. L

Circle 659 on Page 19

Tone Switch

Series 200 ultra-economy tone switch has a current rating of 250 ma at 115 v ac and 1.75 amp at 24 v dc. It can be supplied as a two or three-position unit with 3, 4, 6, or 9 contact clips. Details are found in Bulletin EP-771. Globe-Union, Inc., Centralab Div., 900 E. Keefe Ave., Milwaukee 1, Wis. K

Circle 660 on Page 19

Seamless Tubing

Technical Data Card 193 deals with matching tubes to jobs with 4340 and 4620 seamless mechanical tubing. Aid in choosing the steel and type of tube is offered, as is technical data. Machinability and thermal treatment are covered. 6 pages. Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa. G

Circle 661 on Page 19

"There's no substitute for experience"

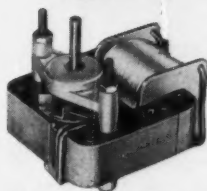
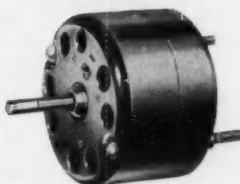
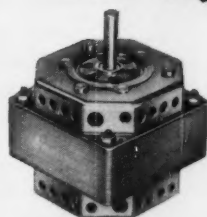
During the past 40 years General Industries has produced millions of electric motors for users throughout the world . . .

It's literally true that any device or machine is only as good as the motor that powers it. That's why leading manufacturers around the world prefer to rest their reputation on GI Smooth Power motors. They know that with 40 years' experience in designing and building sub-fractional-hp motors for every requirement, GI can be counted on to produce the best motor for the job, at the lowest possible price. Next time you have to make a decision on a motor, remember, "There's no substitute for experience." Specify GI motors: quality-proved, millions of times over!

Smooth Power

AC MOTORS 1/1800 H.P. TO 1/35 H.P.
TO MEET EVERY REQUIREMENT

Catalog Available on Request

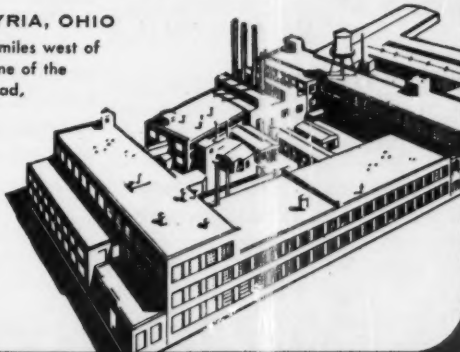


MAIN PLANT: ELYRIA, OHIO

Conveniently located 25 miles west of Cleveland on the main line of the New York Central Railroad, and 16 miles from Cleveland airport.

Other General Industries' plants:

- Belleville, Ohio
- Marysville, Ohio
- Bald Knob, Arkansas
- Putnam, Connecticut



THE GENERAL INDUSTRIES CO.

DEPT. GK • ELYRIA, OHIO

Circle 502 on Page 19

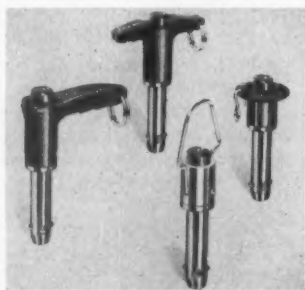
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Quick-Release Pins

incorporate four-ball locking element

Quick-release pins are designed to replace bolts and nuts for increased safety and speed of locking and removal. Lockwell pins incorporate a four-ball locking element for increased tension properties. Handles are designed for optimum opera-



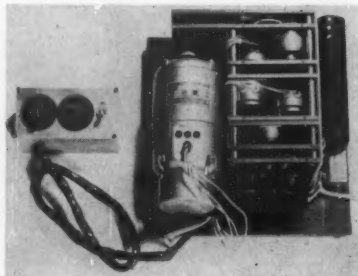
tional clearance, and oversize, quick-release button is anodized bright red for instant identification. Pins are designed for fail-safe operation and continue to be operational even if handle is accidentally broken. Pins are produced in four standard handle configurations and a wide range of sizes. Hartwell Aviation Supply Co., 9035 Venice Blvd., Los Angeles 34, Calif. L

Circle 662 on Page 19

Miniature Transmission

has 15 speeds from 3.3 to 7812 rpm

Case dimensions of compact miniature transmission, excluding power source and control panel, are 4 1/4 in. in width, 7 1/4 in. in length, and 3 5/8 in. in height. Unit has 15 precisely controlled speeds from 3.3 to 7812 rpm, electronically controlled by the use of magnetic clutches with desired speeds obtained by dialing. No manual shifting of gears is necessary. Torque devel-



oped at the various speeds ranges from 50 to over 100 oz-in. All gears and shafts used are either No. 303 stainless steel or 2024-T aluminum which offer extreme resistance to corrosion. Input motor is reversible and delivers speeds and torques in either direction. Motor speed is self-governed and accurately maintained at 8500 rpm. Units operate on 115-v, 60 or 400-cycle current. Transmission is presently in prototype stage. Dynamic Gear Co. Inc., 20 Merrick Rd., Amityville, N. Y.

Circle 663 on Page 19 D

Flexible Coupling

of heat-treated aluminum alloy

Gelder coupling consists of two flanges with steel drive pins molded in and joined together by a laminated fabric and synthetic-rubber disc. Coupling is accurately balanced for operation at and above 3000 rpm, depending upon size. Six sizes are available, with bore sizes



from 7/8 to 3 1/8 in. and horsepower ratings at 100 rpm of 0.25 to 7.12. Unit requires no lubrication, is corrosion resistant, and sparkproof. Coupling Div., Van Gelder Mfg. Inc., 3654 Grand Ave., Oakland 10, Calif. L

Circle 664 on Page 19

Needle Valve

has operating pressure of 10,000 psi

High-pressure, remote-control needle valve, designated Model 4888, has a conventional needle-type stem coupled directly to a pneumatically operated diaphragm mounted on valve body, producing over-all height of only 5 in. Ratio of line pressure to control is in excess of 200:1, giving unit an operating pressure of 10,000 psi with less than 50 psi control pressure. Conventional methods of control are used,



and choice of body and stem materials is available. Extremely strong, durable diaphragm is Buna-N and nylon. Valve, which has only three moving parts, is available in sizes 1/8 through 1/2 in. NPT, as well as AND 10050 tube sizes 4 through 8. Dragon Engineering Co., Inc., Box 185, Norwalk, Calif. L

Circle 665 on Page 19

Positioning Device

prevents torque feedback from either direction

Dual torque-locking and positioning



Barden Precision SR1-4 miniature bearings as used in a linear or non-linear potentiometer.

BARDEN miniature-size bearings are built with instrument precision



The Talyrond, a super-accurate measuring device, is used by Barden as a development tool; as a standard for correlation of other quality control instrumentation; as a gage for ultra-precise bearing parts. It measures roundness and waviness to five millionths of an inch.

Precision-built potentiometers require concentric, smooth-running wiper contacts and ultra low torque characteristics to provide accurate and rapid response to small motivating forces.

Barden Precision miniature-size bearings have the inherent concentricity, smoothness and low torque values to assure this sensitive response and electrical accuracy.

Barden Precision miniature bearings are built to the same high standards of consistent quality as Barden's larger instrument sizes. *Barden Precision* means not only dimensional

accuracy but performance to match the demands of the application.

Your product needs *Barden Precision* if it has critical requirements for accuracy, torque, vibration, temperature or high speed. For less difficult applications, *Barden predictable* performance can cut your rejection rates and teardown costs.

Write today for your copy of Catalog Supplement M1 which gives dimensions, performance and engineering data on *Barden Precision* ball bearings $\frac{3}{16}$ " O.D. and smaller.

THE BARDEN CORPORATION

208 Park Ave., Danbury, Connecticut • Western office: 3850 Wilshire Blvd., Los Angeles 5, California

SPECIFY **BARDEN PRECISION** BALL BEARINGS FOR: INSTRUMENTS • AIRCRAFT ACCESSORIES • COMPUTERS AND RECORDERS • MACHINE TOOL AND TEXTILE SPINDLES • OTHER PRECISION APPLICATIONS

Circle 503 on Page 19

STACKPOLE *Quick-filming* BRUSHES

THE FIRST COMPLETE HIGH-ALTITUDE LINE

Just seat Stackpole Quick-Filming Brushes and they're ready for immediate high-altitude operation. Now available in 5 basic materials groups, these brushes cover practically any high-altitude requirement, present or pending.

Features include excellent commutation; greater stability; lower, more stable temperatures and materially longer life. Uniformly distributed high-altitude protective ingredients reduce maintenance and frequently add greatly to operating stability at high temperatures.

Write for Quick-Filming Bulletin 21.

GRADE 566 (Electrographic series)

... for long life ... improved commutation and operating stability ... lower temperatures ... minimized polarity effect.

GRADE 497 ("Concentrated moly" series)

... for top performance on "trouble" jobs.

GRADE 436 (Metal Graphite Series)

... for slip ring applications and low-voltage commutating equipment.

GRADE 611 (Treated Copper-Graphite Series)

... for slip ring applications and very low-voltage commutating equipment.

GRADE ES340 (Treated Silver-Graphite Series)

... for slip rings requiring low, stable contact drop; also for very moist, very dry, oil vapor or other difficult environments.

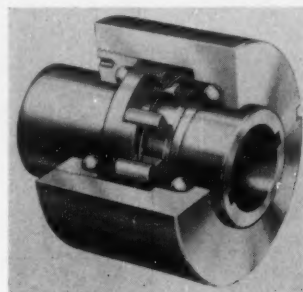


STACKPOLE CARBON COMPANY, St. Marys, Pa.

BRUSHES for all rotating electrical equipment • ELECTRICAL CONTACTS • BEARINGS • GRAPHITE CHEMICAL ANODES • GROUNDING ANODES • POWER TUBE ANODES • SEAL & CLUTCH RINGS • VOLTAGE REGULATOR DISCS • HEATING ELEMENTS • FRICTION SEGMENTS • CERAMIC MAGNETS • FERROMAGNETIC CORES • FIXED & VARIABLE RESISTORS • WELDING CARBONS ... and many other carbon, graphite and metal powder products.

NEW PARTS AND MATERIALS

device drives, positions, overruns, and backstops in two directions. It also provides automatic and positive prevention of torque feedback from either direction. Device is compact, has high torque capacity, and is designed for high overrunning speeds. It delivers maximum torque for size and weight, and assures equal radial loading with two opposing sets of full-complement sprags. Design permits free rotation and transmission of high driv-



ing torque in either direction from input to output shaft. Device also can be used as a two-directional overrunning clutch and for reversing and two-speed drive applications. **Formsprag Co.**, 23601 Hoover Rd., Warren, Mich. T

Circle 666 on Page 19

Printed-Circuit Connectors

miniature units have current rating of 3 amp

Miniature printed-circuit connectors for printed-tape cable or printed-circuit board applications are available in two series, designated 600-4PCSC-13 for 13-contact unit (shown) and 600-7-1 for 18-contact unit. Both connectors have current rating of 3 amp and feature staggered placement of contacts to assure ease of wiring. Molding is glass-reinforced diallyl phthalate per MIL-M-19833, Type GDI-30. Contact material is spring-temper phosphor bronze, gold plate over silver

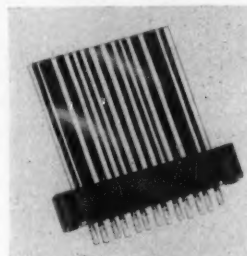


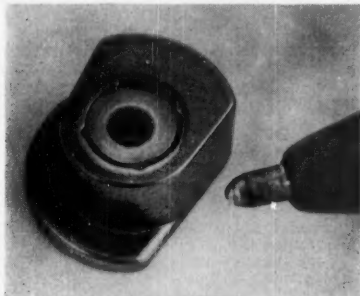
plate. Series 600-4PCSC-13 accepts 1/32-in. board or cable; module design of molding permits stacking in any reasonable quantity. Series 600-7-1 is for 3/64-in. board or cable. Electronics Div., DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 667 on Page 19

Self-Aligning Clamps

fasten components with base flanges or grooves

Self-aligning, stainless-steel clamps, designated Synclamps, are available in eight different sizes with same OD of 0.39 in. max. They permit secure fastening of components with base flanges or grooves, and are well suited for hard-to-reach places. Fasteners are self-aligning, self-locking, and withstand extreme environmental conditions. Incorporation of nylon inserts permits quick, easy self-alignment. When screw is tightened, nylon insert is stripped, allowing clamp to self-align per-



fectly. Clamp seats tighter as screw is turned. Timber-Top Inc., 36 Brooklyn Ave., Freeport 8, L. I., N. Y. D

Circle 668 on Page 19

Two-Circuit Switches

have median lifetime of 10 million operations

Snap-action, two-circuit, precision switches, Type 3MN, are for use on machine tool limit and control mechanisms. Switches have median mechanical life of over 10 million operations at full overtravel. Three of the switches have a combined stacking width of only 2.03 in. Step-design, arc-resistant plastic case provides extra space between integral terminals, reducing possibility of shorting. One mounting hole is

Browning

COMBINES THE POSITIVE ACTION OF GEARS

with THE FLEXIBILITY OF BELTS

NEW



GEARBELT DRIVES

GEARBELT ADVANTAGES:

- ▶ **A POSITIVE DRIVE.** No slip, creep or backlash.
- ▶ **STEEL CABLE** strength member will not stretch, needs minimum take-up.
- ▶ **FREEDOM** from high initial belt tension. Reduces bearing loads, increases life.
- ▶ **COMPACT.** Gearbelts permit smaller pulleys, shorter centers, narrower belts.
- ▶ **LIGHTWEIGHT.** High horsepower-to-weight ratio.
- ▶ **LESS NOISE.** No vibration, no chatter.
- ▶ **LESS HEAT** because virtually no friction.
- ▶ **SPLIT TAPER BUSHING** grips pulley on shaft with vise-like pressure. Quick, easy mounting and removal.

Here is a versatile new drive that provides high mechanical efficiency *plus* the inherent flexibility of belts. Browning Gearbelts engage matching pulleys with the positive action of gears, yet without their disadvantages. They eliminate metal-to-metal contact, lubrication, vibration, chatter. Require minimum maintenance.

Browning Gearbelt Drives provide cost-saving advantages in scores of applications, particularly those which require high capacity in limited space, or freedom from stretch and take-up. Ask your Browning distributor for complete information, or write us for Catalog GB-201.

Browning Manufacturing Company
Maysville, Kentucky

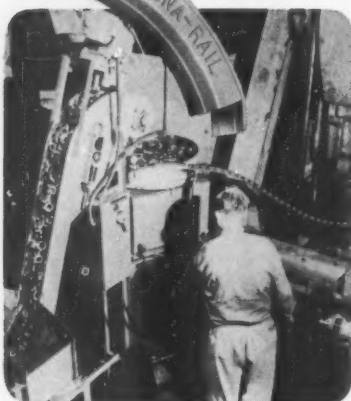
Browning

POWER TRANSMISSION EQUIPMENT

COUPLERS • PAPER PULLEYS • BEARING UNITS

MAGNETS PLUS AUTOMATION EQUALS MAGNAmation®

New word from
ERIEZ
New efficiency
for industry



MAGNA RAILS. Lifetime powered, non electric magnetic elements that convert ordinary belt conveyors to magnetic conveyor elevators. Will convey ferrous items up inclines as steep as 90° — quickly, safely, with positive hold. Easily installed under existing lines, or incorporated into new equipment. Increases production. Reduces manpower needs. Saves valuable factory floor space.

VERSATILE MAGNA RAILS ARE AVAILABLE IN MANY MAGNETIC STRENGTHS IN VARIOUS BOLT-TOGETHER LENGTHS AND IN STRAIGHT AND CURVED SECTIONS, ASSURING YOU PROPER UNITS FOR SOLVING YOUR HANDLING PROBLEMS REGARDLESS OF SIZE OF PARTS.



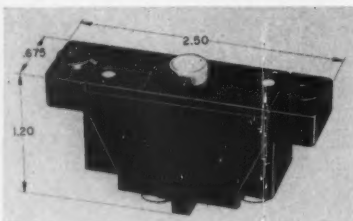
We work closely with design engineers, OEMs, etc. Contact us any time.

FREE! Comprehensive "Belt Conveyor" portfolio. Complete info on magnetic components, applications, test data, installation photos, etc. Write today to Eriez Manufacturing Co., 131-AA Magnet Dr., Erie, Pa.



Circle 506 on Page 19

NEW PARTS AND MATERIALS



elongated to eliminate need for close tolerance in center-to-center distance between mounting holes on equipment. Minimum of 0.08-in. over-travel is provided. Contact arrangement is single-pole, two-circuit, double-break. Series is rated for 15 amp, 120, 240, 480, or 600 v ac. Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill. K

Circle 669 on Page 19

Silicon Solar Cells

have efficiencies
as high as 9 per cent

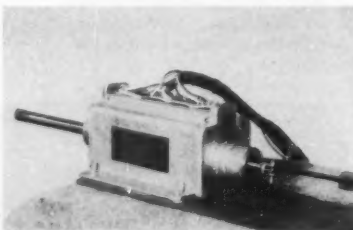
Diffused-junction N2000 silicon solar cells are available in rectangular configuration, measuring 1 x 2 x 0.5 cm, both in single units and shingle arrays. Units possess a high degree of mechanical ruggedness and have efficiencies as high as 9 per cent. When formed into shingle arrays they resist minimum static load of 16 oz per contact without rupture. Units are suitable for application as critical industrial controls. Semiconductor-Components Div., Texas Instruments Inc., P. O. Box 312, Dallas, Tex. P

Circle 670 on Page 19

Linear Positioning Motor

translates simple input into
accurate linear motion

Electrical control device responds to an input with instantaneous linear movement of its shaft to any of several accurate positions. Exact amount of shaft movement is de-



Hoffman JIC and NEMA 12 OIL-TIGHT DUST-TIGHT ELECTRICAL ENCLOSURES

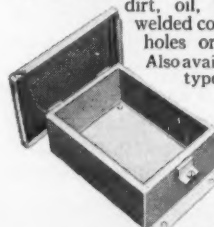
WALL MOUNTED,
in 18 stock sizes.

FLOOR MOUNTED,
in double door or
multiple door
units—11
stock sizes.

JIC
NEMA 12
PANEL

ENCLOSURES

Ideal for housing electrical controls, components and terminal strips. Note removable mounting panel. Neoprene gasket on door protects against dust, dirt, oil, water. Strong welded construction. No holes or open seams. Also available in NEMA types 1, 3, 4 and 5.

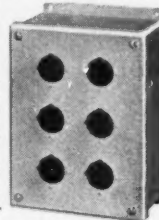


JIC
WIRING
BOX

Heavy gauge steel, welded seams. No knockouts or holes to leak oil, water or dust. Neoprene gasketed cover with screw clamp makes tight oil-proof seal. Available with or without removable panel. 8 stock sizes from 4"x4"x3" to 16"x14"x6".

PUSHBUTTON
ENCLOSURES

A complete selection of types and sizes. Fine quality construction and finish. Welded seams. Cover has neoprene gasket. Holes take any standard oil-tight pushbutton. Types, range from "Standard" as shown, to Extra Deep, Slim and Pendant. For one to 25 pushbuttons.



OIL-TIGHT
JIC SECTIONAL
WIREWAY

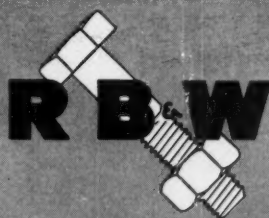


Perfect protection for control wiring. Neoprene gasket on cover and between joints seals out liquids and dust. Easy to assemble. Full length hinged cover simplifies wiring installation or modification after installation. Stock sizes: 2½"x2½", 4"x4" and 6"x6" in lengths up to 10' with Elbows, "T"s, etc.

We also build enclosures to customer specifications

Hoffman ENGINEERING CORPORATION
Dept. MD-122 Anoka • Minn.

Circle 507 on Page 19



FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY



Technical-ities

By Fred E. Graves

Why cap screws instead of studs?

Many types of products once fastened with studs are today assembled with cap screws. Why the change in preference?

Studs show certain advantages in large diameters and in high temperature applications. But when it comes to smaller sizes used in tapped holes, designers and production people have found more advantages in cap screws.

ASSEMBLY FACTORS

In fastener selection for a given application, you have to consider production and assembly as well as joint strength.

Obviously, studs require two wrenchings (first stud, then nut). Also, there's a more expensive close tolerance tapping job, since a stud takes an interference fit to stay tight and not withdraw when nut is backed off.

Cap screws require only a clearance fit. Used in a tapped casting, they can be repeatedly inserted and unscrewed without damage to threads.

HOW NOT TO USE STUDS

Studs are not meant to serve as dowels to locate and line up for fastening. To line up numerous studs and bring two pieces together raises assembly cost. Use dowel pins for alignment and use cap screws for fastening to achieve greater economy.

Screw develops high thread tension . . . and stays locked in place



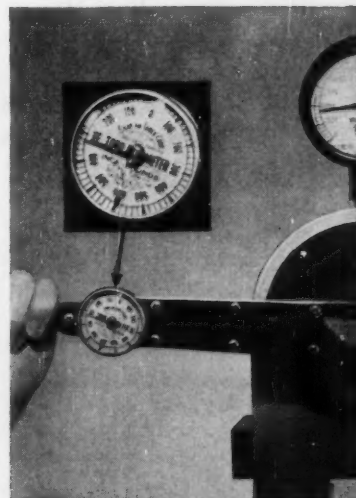
RB&W TENSILOCK screw, despite the friction of the toothed flange, develops 4000 pounds tension with on-torque of 240 inch-pounds.

Here is a locking fastener where the on-torque effort not only *anchors* the screw but also develops high preloading, or residual tension.

Like high tensile cap screws, RB&W's TENSILOCK® screws also give a high thread tension to torque ratio. But there's one important difference. The TENSILOCK fasteners lock with *teeth* as well as high residual tension.

RATCHET-LIKE LOCKING

Carburized teeth on flange of this one-piece fastener are so angled as to afford easy torquing. They bite into the seating surface when fastener is fully tightened. A circular groove in the flange increases flexing action and enables flange to



An off-torque of 330 inch-pounds fails to break loose the grip of the teeth. Tension is maintained by TENSILOCK screw.

maintain pressure on the imbedded teeth. To *loosen* a tightened TENSILOCK fastener thus takes much more effort than the on-torque. And it can be reused with little loss of this holding power.

FRICTION STOPS SLIPPAGE

The full clamping force exerted by these fasteners prevents slippage of the fastened members where lateral movement is possible because of large or eccentric holes. The positive gripping enables them to stay tight even under conditions of severe vibration or cyclic temperature fluctuations. RB&W TENSILOCK nuts also available. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

*Trademark Pat. applied for

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Take ALL the Problems Out of Your Variable Speed Requirements

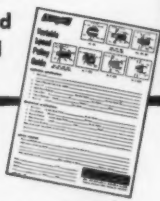
Put Lovejoy's exclusive individualized service to work for you...a complete line of variable speed pulleys and transmissions—plus personalized engineering guidance to assure full satisfaction.

Here's how it works...

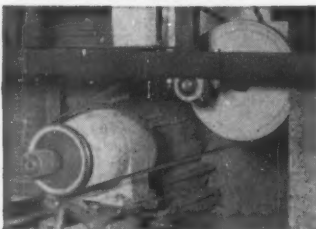
a simple and convenient two-step plan:

① Lovejoy sends you full information on the types of variable speed pulleys and transmissions available... along with a guide sheet to help you supply us with pertinent information on the type you need and the service you require.

- Speed ratios: up to 10 to 1
- Horsepowers: fractional to 15
- Constant belt alignment
- Instant speed changes while equipment is running
- Easily installed on new or old equipment.



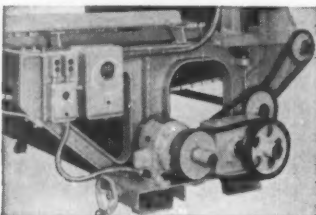
TYPICAL EXAMPLES:



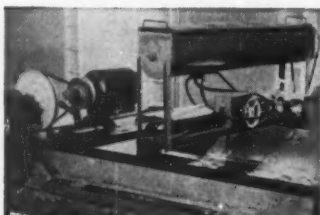
Type 160 Pulley and No. 200 Tilting Motor Base proved the right combination for a mailing machine.



Type 135 Pulley meets all requirements on a vibrating machine.



Proper drive for a lat bed rip saw is provided by a Type 302 Pulley.



This Lovejoy "double" solved a grading machine problem—Type 145 Pulley and No. 2 Select-O-Speed.

Save time and expense. Get your Variable Speed Pulley Guide by requesting Form 118F today.



LOVEJOY FLEXIBLE COUPLING CO.

4818 WEST LAKE STREET

CHICAGO 44, ILLINOIS

NEW PARTS AND MATERIALS

terminated and selected by simple input devices such as switches, relays, pushbuttons, and contacts. Repeatability within 0.005 in., travel time of 100 millise, and thrust of 100 lb or more are possible. Shaft of motor is only moving part, moving in linear direction only. It is also free to rotate with attached load if necessary. Shaft can be attached either to a load that requires only simple positioning, or to a load that requires linear positioning superimposed on existing rotary motion. Motor has an unlimited number of positions with resolution of 0.01 in. Both coarse and fine positioning can be supplied. Tronics Corp., 3324 Hiawatha Ave., Minneapolis, Mnn.

Circle 671 on Page 19

Midget Nut

for pressures to 160,000 psi



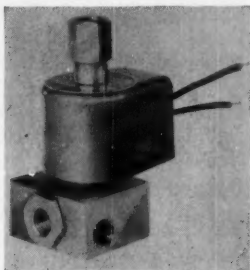
Kaylock H14-02 all-metal, lightweight, 160,000-psi, self-locking nut is useful for fastener applications in electronic systems of missiles, rockets, and aircraft. Physical maximum dimensions are height, 0.095 in., base diam, 0.172 in., wrench hex size, 3/32 in., and weight, 0.02 lb per hundred. Kaynar Mfg. Co. Inc., Box 2001, Terminal Annex, Los Angeles 54, Calif.

Circle 672 on Page 19

Solenoid Valves

midget units have full 1/4-in. diam exhaust orifice

Three-way quick-exhaust solenoid valves, No. 8317, are for use with water to 100 F and air, gases, and light hydraulic oil to 180 F. Oversized 1/4-in. diam exhaust orifice is an integral part of body, eliminating need for connecting a separate quick-bleed valve in circuit to speed up exhaust cycle. Direct-acting valves have brass bar-stock bodies with 1/4-in. NPT connec-



tions. Discs are resilient and nylon, providing tight seating at pressures to 160 psi. Valves can be mounted in any position without affecting operation. Normally closed, normally opened, and universal forms of operation are available. Valves are provided in any voltages to 550 v, 60 cycles. Automatic Switch Co., Florham Park, N. J.

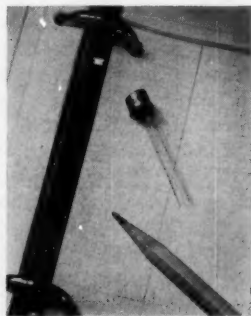
D

Circle 673 on Page 19

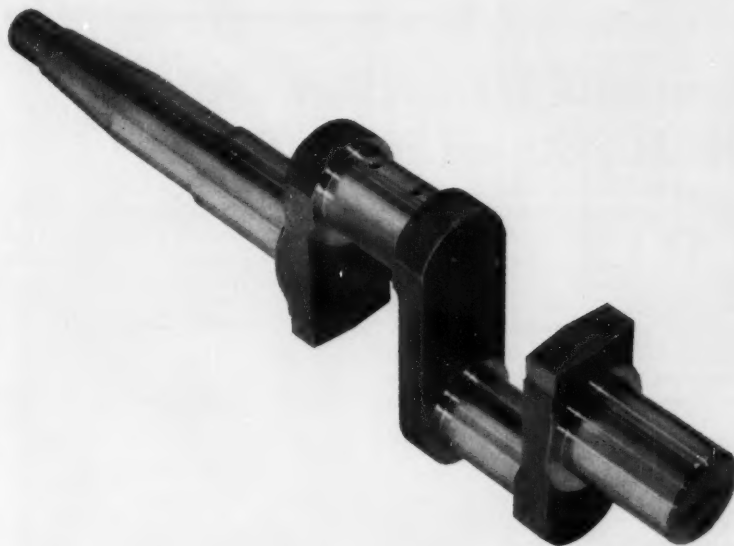
Silicon Transistors

for amplifier and switching use

Four high-frequency NPN silicon transistors for use in military and industrial equipment have minimum alpha cutoff frequency rating of 15 megacycles. JEDEC type-designated 2N1276, 2N1277, 2N1278, and 2N1279, they are designed for general-purpose amplifier and switching use. Fixed-bed pellet-mounting design provides high mechanical reliability under extreme conditions of shock, vibration, centrifugal force, and temperature. Devices have typical 1000-cycle power gain ratings of 37, 39, 44, and 45 db respectively, which is higher than most silicon transistors of this type. Collector-to-base voltage rating is 40 v, and temperature range is -65 to +200 C. Transistors are housed in metal



January 7, 1960



RIGIDITY

A CASE IN POINT—This seventy pound ductile iron crankshaft is made for compressors manufactured by The Brunner Division of Dunham-Bush, Inc. The increased loads and speeds called for by new compressor design specifications required rigidity and strength beyond the limits of the cast iron alloy shafts formerly used. Ductile iron was chosen because the rigidity, tensile strength, fatigue strength and wear characteristics comfortably exceed operating requirements. A major bonus—the existing pattern equipment could be used for the ductile iron castings, thus saving the high cost of dies needed for steel forgings.

Ductile iron has most of the engineering advantages of steel yet it can be designed with the same flexibility and cast with the same procedures as gray iron. The 120-90-02 grade used in this case has an elastic modulus of about 24×10^6 psi, 42,000 psi endurance limit, and 300 BHN. The 120,000 psi tensile strength is double that of the previous crankshaft. Hamilton Foundry regularly casts all grades of ductile iron and high alloy Ductile Ni-Resist.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules—will be met.

GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (NODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD



HAMILTON FOUNDRY INC.

1551 LINCOLN AVENUE • HAMILTON, OHIO • TWInbrook 5-7491

Circle 510 on Page 19

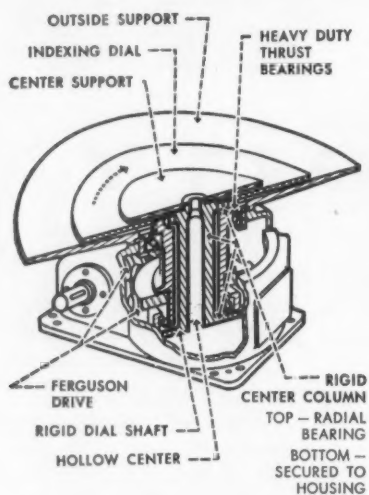
183

DESIGN CONSIDERATIONS

How INDEX TABLE DESIGN Affects INITIAL PRICE and TOTAL COST

Study these drawings to see how the design of an index table affects total costs of an installation. Some tables may be priced lower than others initially, but the additional charges for auxiliary items to adapt them to production requirements, added to maintenance and downtime costs, can make a drastic difference in the total price.

FIG. 1—FERGUSON INTERMITTOR



The Ferguson Intermittor, indexed by a roller gear drive which operates a minimum of 8,000 hours at speeds up to 2,000 indexes a minute without maintenance, needs no auxiliary locking. It is designed for high speed operation and incorporates rigid integral supports for tooling to eliminate expensive segmental components. The Intermittor dial is supported by tapered roller thrust bearings to withstand heavy loads with little friction. A stationary center tooling support is held rigidly at its top by anti-friction radial bearings and at the bottom by a flanged base bolted to the housing. Hollow center of the support may be used for passage of coolants, fluids, air or vertical shafts to transmit motion to the work surface.

Figures 2 and 3 show typical barrel cam and geneva drive index tables. Their indexing mechanisms limit operating speeds, therefore other components may be "designed down." Shafts and bearings are lighter; frictional support surfaces might be employed instead of thrust bearings and an auxiliary locking or locating device is a costly necessity for even modest accuracy requirements. Tool mounting methods are often provided at

additional expense and sometimes even ignored. Difficulties of installation and frequent maintenance downtime can increase total cost drastically.

FIG. 2—BARREL CAM TYPE

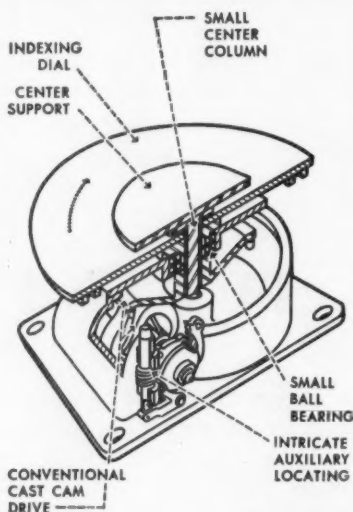
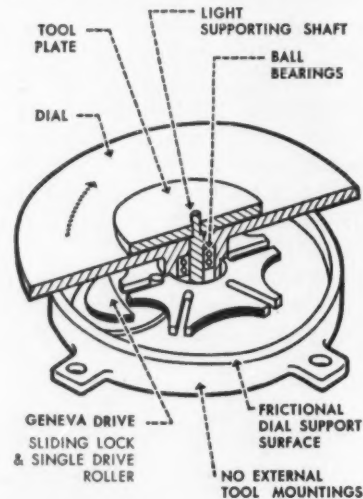


FIG. 3—GENEVA DRIVE TYPE



• SEND FOR CATALOG

Many other advantages result from the selection of a Ferguson Intermittor. Compare designs in new Catalog No. 160 which contains data on more than 175 standard tables. Every design engineer should have a copy. Get yours by writing:

Ferguson Machine Corporation
7818 Maplewood Industrial Court
St. Louis 17, Missouri

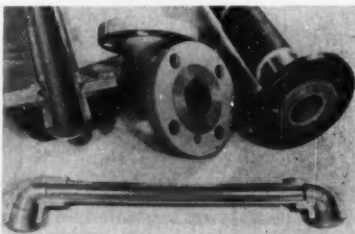
NEW PARTS AND MATERIALS

cases which are hermetically sealed by welding. Semiconductor Products Dept., General Electric Co., Charles Building, Liverpool, N. Y.

Circle 674 on Page 19

Fittings and Pipe

are all-Penton
or Penton-lined units



All-Penton and Penton-lined metal fittings, and metal pipe with injection-molded lining, are available for handling solvents and hot corrosive fluids in process piping. The chlorinated polyether thermoplastic has excellent corrosion resistance and ability to handle elevated temperatures, including low-pressure steam. All-Penton elbows, tees, couplings, caps, plugs, flanges, unions, nipples, reducer couplings, and reducer bushings are furnished in 1/2 to 2-in. sizes, threaded socket type, Schedule 80, to match 20-ft lengths of Penton pipe. Carbon steel and aluminum pipe lined with injection-molded Penton, and Penton-lined cast-iron and cast aluminum flanged fittings, including elbows, tees, and steel-flanged, Penton-lined stub ends, are planned in 1/2 through 3-in. sizes. Tube Turns Plastics Inc., Louisville, Ky.

Circle 675 on Page 19

Flexible Duct

is highly impermeable
and lightweight

Flexflyte L-1 lightweight, reinforced, flexible fabric duct is intended for permanent and semipermanent installations requiring optimum air-flow efficiency. It can also be used for flow of liquids, gases, light solids, and chemicals. Available in 1/2 to 12-in. ID sizes, duct is designed primarily for low-pressure venting in aircraft, missiles, and other automotive applications. It is also for use in many industrial applications where extreme tempera-

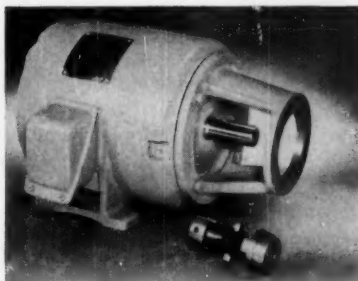
tures are encountered, or where high impermeability of duct is desirable. Operating temperature range is from -65 to +300 F. Neoprene-coated glass-fibre fabric remains fully flexible within this range. Material does not support combustion and is exceptionally flame resistant. Duct operates with working pressure up to 40 psi internally, 15 psig externally. It can be installed without elbows or fittings at angles up to 180 deg. Flexible Tubing Corp., Guilford, Conn. **B**

Circle 676 on Page 19

Hydraulic Pump Motors

have adapter permitting motor-mounting of pump

Hydraulic pump motors in NEMA frames 182 through 215 are available in dripproof, enclosed, or explosionproof construction. Designed with an adapter that allows hydraulic pump to be motor mounted, units are available in all ratings now supplied in 182, 184, 213, and 215 frames, nominally 1 to 5 hp. Pump-mounting adapters can be supplied that accept pumps of many



manufacturers. They are available on both ends of dripproof and enclosed, nonventilated motors. Motors can be supplied with a flexible coupling that assures proper shaft alignment and virtually eliminates unusual bearing loads. General Electric Co., Schenectady 5, N. Y. **C**

Circle 677 on Page 19

Slip-Ring Assembly

has high axial packaging density

Capsule slip-ring and brush assembly has 56 isolated circuits, and rotor is bearing-mounted at both ends. Unit has high axial packag-

Circle 512 on Page 19→

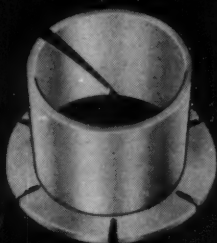
January 7, 1960

185

LONG LIFE, THOMSON "Snap-In"

NYLINERS[®]

-BEARINGS of smooth, tough DuPont NYLON



Low Cost
FLANGED Nyloniner



Low Cost
SLEEVE Nyloniner



Low Cost
DOUBLE-FLANGE Nyloniner

COST LESS to BUY COST LESS to INSTALL & ELIMINATE LUBRICATION

Additional Benefits:

- CLOSE FIT
- LONGER LIFE
- EASILY INSTALLED
- LESS SERVICING
- SELF-RETAINING
- RESIST CORROSION
- LOW FRICTION
- RESIST POUNDOUT
- NO FRICTION OXIDATION
- DAMP VIBRATION
- OPERATE IN LIQUIDS
- NON-CONTAMINATING
- INSTANTLY REPLACEABLE
- RESIST ABRASION
- MINIMUM SPACE
- SILENT OPERATION
- LIGHTEST WEIGHT
- REDUCED WEAR

Engineered to Solve Problems... Improve Products...
Reduce Costs!

NYLINER Bearings are a highly engineered thin liner of DuPont Nylon, designed to bring bearing users the many benefits of Nylon as a bearing material by solving most of the limitations surrounding its use. The compensation gap principle assures maintenance of diametral tolerances for precision applications.

Seven Standard Types available from stock. Write for literature and name of your local representative who stocks NYLINER Bearings for immediate shipment.



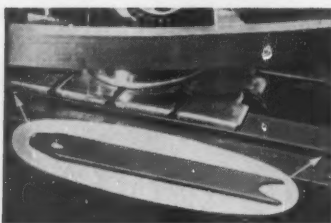
THOMSON INDUSTRIES, Inc.

DEPT. 4, MANHASSET, NEW YORK

Also—

Manufacturers of BALL BUSHINGS... the Ball Bearing for Linear Motions and 60 CASE... Hardened & Ground Steel Shafting

POLYPENCO® NYLATRON® GS SHAPES



Stock shapes of Nylatron GS assure rapid, low cost parts fabrication. (Upper left) Small bobbin requiring close tolerance, produced on high speed automatic screw machine from Nylatron GS rod. (Lower left) Proof of performance: Nylatron GS wear strips outlast metal, reduce wear on conveyor chain and stand.

Special properties of NYLATRON GS nylon provide parts with unusual wear life

One of the newest industrial plastics available to designers is POLYPENCO Nylatron GS nylon—supplied in standard stock shapes. Nylatron GS is a molybdenum disulphide filled nylon composition*. This special formulation results in a product with proven property advantages:

Greater Rigidity

Parts have higher modulus of elasticity, show less deformation under load than nylon 101.

High Heat Distortion Temperature

Nylatron GS parts have higher heat distortion temperatures than standard nylon 101.

Low Thermal Expansion

Coefficient of thermal expansion is

approximately 60% of nylon 101.

Low Surface Friction

When wear parts must run dry, Nylatron GS parts operate without lubrication.

High Wear and Abrasion Resistance

Part surfaces resist abrasion and demonstrate long wear in contact with metals.

The chemical and electrical properties are similar to nylon 101.

Nylatron GS is available in all standard shapes and sizes including rod, strip, tubing, tubular bar and plate. It is also available in powders for molding. Write today for performance and application data on POLYPENCO Nylatron GS nylon.

*Patents applied for

THE POLYMER CORPORATION OF PENNA.

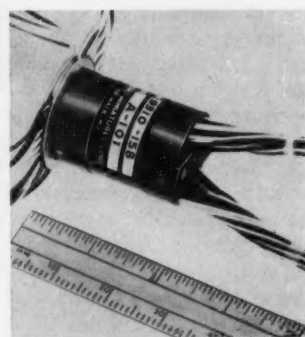
Reading, Pa.

Export: Polypenco, Inc., Reading, Pa., U.S.A.



POLYPENCO Nylon, POLYPENCO Teflon†, NYLAFLAW and NYLATRON® GS †DU PONT TRADEMARK

NEW PARTS AND MATERIALS



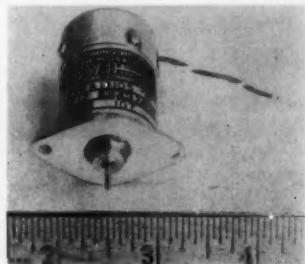
ing density, with total length of 0.982 in. OD is 0.624 in., with exception of drive flange, which is 0.75 in. in diam. Leakage resistance is more than 20,000 megohms at 500 v dc between all circuits and between each circuit and ground. Current ratings are 0.5 amp on 12 circuits and 0.25 amp on remaining 44 circuits. Lead wires are No. 28 and No. 30 AWG. Torque required is 65 gm-cm for reliability at 25 g between zero and 2000 cps. Electro-Miniatures Corp., 600 Huyler St., South Hackensack, N. J. D

Circle 678 on Page 19

DC Motors

subminiature units have high torque, reversibility

Subminiature, reversible dc motors, Series 14100, have extreme compactness, high torque, low rotor inertia, and high efficiency. Measuring less than 1 in. diam, 1 3/8 in. long, and weighing only 2 oz, units are recommended for use in repeat-cycle timers, time-delay relays, tape recorders, printed-circuit commutators, and as potentiometer drives. They can also be used as low-voltage generators. Rotor assembly permits speed tolerance of ± 10 per cent at rated voltage. Standard units are available for operation on voltages from 4.5 to 30 v dc, and special windings can be supplied for



other voltages. Temperature range is -54 to +85 C. A. W. Haydon Co., 232 N. Elm St., Waterbury, Conn. B

Circle 679 on Page 19

Light-Operated Switch

turns on at 1 ft-c
and off at 10 ft-c

Lightguard is a small, automatic, light-operated switch only 1 3/4 in. in diam. It is designed to turn on at approximately 1 ft-c and off at 10 ft-c. Currently manufactured models are suitable for tungsten loads to 300 w on 120-v ac circuits. Unit is not affected by either weather or temperature, and is



sealed in moistureproof case. Built-in time delay prevents switch from being activated by temporary light flashes. Schacht Electronic Mfg. Co., 1213 Saint Emanuel, Houston 3, Tex. P

Circle 680 on Page 19

One-Part Sealant

resists oxidizing metals

One-part sealant, designated Gray-guard Mastic, bonds tightly to most engineering and structural materials, then self-cures to a resilient rubber seal. Properties suggest a wide range of applications, both as a basic material in manufacturing as well as a universal sealant for new construction and plant maintenance. Mastic serves as a cure-in-place gasket for a variety of equipment. It effectively seals pumps, piping, ductwork, and housings, and withstands most rubber-deteriorating liquids and atmospheres, dampens vibration, and reduces noise. It is suitable for uses involving repeated expansion and contraction, since it is a true elastomer. Sealant can be compounded in any solid color, pastel, white,



...Better still with new MF Whiz-Locks®

One-piece free spinners
that won't let go. So simple they'll amaze you.
So original there's a patent pending.



MacLean-Fogg's new Whiz-Lock is a one-piece, free-spinning lock nut that is simplicity itself. Spin it into place, wrench it tight and forget it. The scientifically designed spiral teeth take just the right grip on the work to prevent accidental loosening. Yet it removes readily on application of at least 25% more torque than was used to apply it.

MF Whiz-Locks have been as thoroughly tested as any new fastening device ever offered. Test them yourself soon. Samples are available free. Ask for hex nuts or bolts—with or without flange—in sizes from No. 6 to 3/4". State size desired.

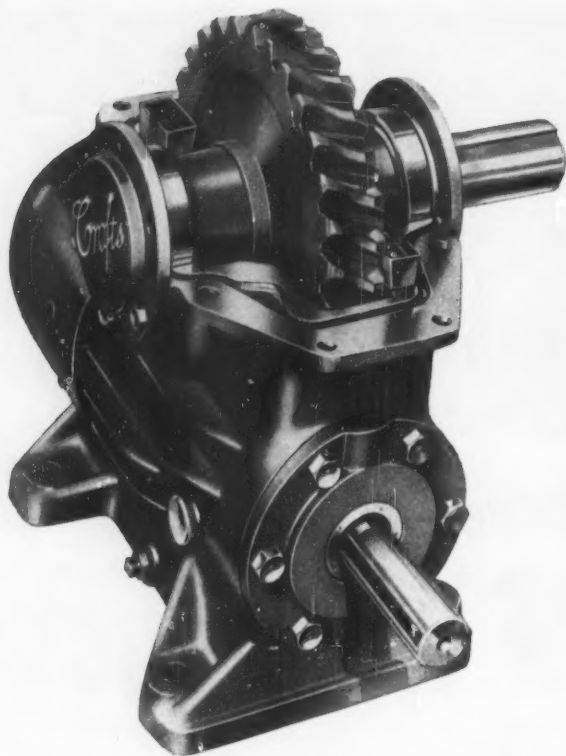
SEND FOR SAMPLES

MAC LEAN-FOGG

LOCK NUTS

MacLean-Fogg Lock Nut Company
5535 N. WOLCOTT AVENUE
CHICAGO 40, ILLINOIS

1926 **35** 1960
ANNIVERSARY



CROFTS "RADIATION" WORM GEAR REDUCERS . . . FAN COOLED

CROFTS fan-cooled worm gear reducers are designed to provide maximum power outputs in minimum case dimensions.

Ordinarily, this would mean trouble from overheating.

But not with CROFTS 'Radiation.' Temperature rise is effectively con-

trolled by a fan fitted to the worm shaft. This directs a steady stream of cool air along exterior ribs on the gear case surrounding the worm. Vertical ribs on the upper half of the case, plus the large surface area, dissipate remaining heat and maintain maximum operating efficiency.

- **CASING** . . . constructed of Crofts Semi-Steel, a super quality, close-grained metal of good surface finish and fine machining qualities. Machined oil-tight and dustproof.
- **WORM** . . . is of Crofts Special "Wormsteel," integral with its shaft. Hardened, ground, polished and finished to fine limits.
- **WORM WHEEL** . . . of "Croftspan" Special phosphor bronze, centrifugally cast; rim shrunk and pegged to a semi-steel center. Teeth hobbed to fine limits.
- **BEARINGS** . . . High quality dual purpose ball bearings for both wheel and shafts adequately provide for radial and thrust loads.
- **LUBRICATION** . . . is provided by a positive lubricating system directing a continuous flow of oil over meshed surfaces of worm and wheel, and also to the bearings.

Available from stock up to 100 hp., ratios up to 60-1 at input speeds from 100 to 1800 rpm.

Get prompt quotation and recommendations on your standard or special requirements. For general information ask for Gear Reducer Bulletin E-751.

CROFTS U.S.A. INC.

2542 West Peterson Avenue

Phone: ROgers Park 1-0019

Chicago 45, Illinois

EASTERN STATES DISTRIBUTOR

Rockwood Pulley Mfg. Co., Inc., 20 Crosby St., New York 13, N. Y.

CROFTS CANADA LTD.

2185 Madison Avenue
Montreal 28, P. Q.

25 Jutland Road
Toronto, Ont.

Circle 515 on Page 19

NEW PARTS AND MATERIALS

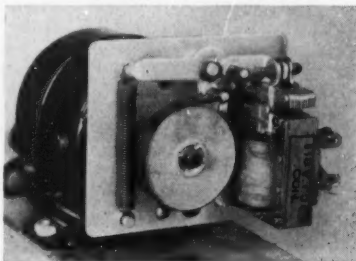
and black. Mastic, applied with a putty knife, caulking gun, or trowel, retains rubberlike qualities over temperature range from -40 to +250 F. Grayguard Inc., P. O. Box 1644, Wilmington 99, Del. C

Circle 681 on Page 19

Small Brake

for fractional-horsepower electric motors

Low-cost, precision-built brake for small fractional-horsepower electric motors is suitable for use in stopping overtravel on vending machines, computer mechanisms, tape transports, turntables, and other mechanisms where positive stop is necessary. Unit has braking torque of 2 to 4 lb-in. for shafts to $\frac{3}{8}$ in. Brake uses a band that almost completely encompasses brake drum. Constant-duty solenoid, furnished



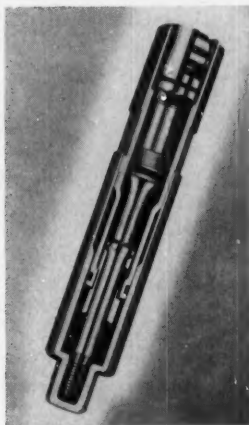
in ac only, is connected in parallel with motor. When motor is activated, solenoid depresses a pivoting arm, which loosens brake band. When power to motor is cut, solenoid releases pivoting arm. Stainless-steel spring pivots arm upward, tightening brake band against shoe. Without load, motor is stopped in less than one-quarter revolution. Midwest Automatic Control Co., 510 Third St., Des Moines 9, Iowa. I

Circle 682 on Page 19

Liquid Spring

has flat top wave

Model 1040SS Liquid Spring Shok produces spring action by liquid compression between sealed area at stud head and sealed area of tubular piston, providing net compression of liquid to 20,000 psi. Shock force is produced by inwardly turned dashpot head at tubular piston end plus inertia-valve area. First 0.030-in. compressive movement of



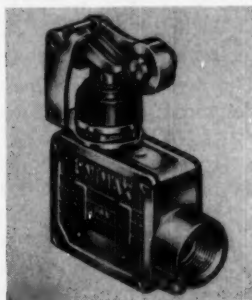
piston closes inertia valve, forcing liquid to pass dashpot head between tapered metering stud and valve inner bore. Due to tapered stud, dashpot resistance provides 6000 lb average maximum force for a flat-topped energy absorption diagram for maximum energy absorption at minimum force with declining velocity and cam slopes. Dashpot metering area varies from 0.008 to 0.004 sq in. at end of 0.68-in. stroke. At termination of compressive stroke, inertia valve opens, providing restoring liquid-spring force of 1000 lb against cam to extend at high velocity within 0.5 sec. Taylor Devices Inc., 188 Main St., North Tonawanda, N. Y. N

Circle 683 on Page 19

Enclosed Switch

has adjustable roller arm

Unimax adjustable-roller-arm enclosed switch consists of a basic 2HB-5 single-pole, double-throw, snap-acting switch in a die-cast aluminum housing. It has a sealed overtravel plunger and adjustable roller-lever actuator suitable for operation by either fast or slow cams



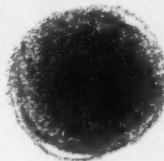
Hang-up



Pop-off



Blackout



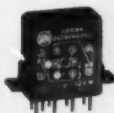
(These are horrible things that can happen to relay contacts.)

To know and recognize these maladjustments is to take the first step toward avoiding them. They are most apt to show up, singly or in concert, when you apply a slowly changing energizing signal to a relay designed for "on-off" operation only (single and sudden glops of power).

"Pop-off" is the name someone has given to a slow let-up in contact pressure, causing the contacts to lightly kiss when they should have parted abruptly—a sort of disastrously lingering farewell. "Hang-up" is much the same thing, but occurring at or near the other end of the armature's travel: although the armature has moved across the gap, the contacts aren't firmly closed—a sort of timid hello. The third horror—"blackout"—is complete demoralization of the armature: it stops in mid-gap, a victim of friction. This is center-neutral operation—when it's least wanted.

The only way we know of to avoid these things is to get a relay which has been intelligently designed and built to operate

on sliding or slowly changing current. The manufacturer has then taken pains (and probably gotten a few) to arrange the physical and magnetic forces in such a way that the armature has no choice but to go all the way—quickly and resolutely—the moment the current reaches the operate point.



The Sigma Series 33 is just such a current-sensitive relay, conscientiously designed and manufactured to work in your circuit without ever popping off, hanging up or blacking out. It is a DPDT polarized relay with magnetic bias (armature normally occupies one closed position when unenergized); has a standard operating sensitivity of 200 mw., withstands 30 g to 5000 cps vibration and 100 g shocks with no contact opening, energized or not. The price is not that of an on-off relay, but then neither is the performance. If you need operation on sliding current, a "33" will do the job. Bulletin on request.

SIGMA

SIGMA INSTRUMENTS, INC.

89 Pearl St., So. Braintree 85, Mass.

AN AFFILIATE OF THE FISHER-PIERCE CO. (Since 1930)



Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive

and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD-66v.

DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

COFFING HOIST DIVISION • Danville, Illinois

DUFF-NORTON JACKS

Ratchet • Screw
Hydraulic • Worm Gear



COFFING HOISTS

Ratchet Lever • Air
Hand Chain • Electric

NEW PARTS AND MATERIALS

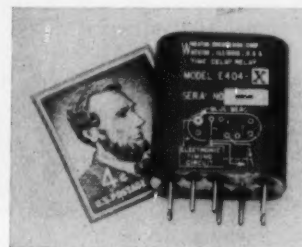
or slide-actuating devices. Actuator arm can be adjusted through 240 deg around its shaft, and actuator bracket can be rotated about plunger and locked in any of eight positions, 45 deg apart. No. 1/2-14 internally threaded hub at one end of case permits installation in standard electrical conduit system. Basic switch in unit is rated at 20 amp, 125, 250, 480 v ac. It can also be furnished with horsepower ratings of 3/4 hp, 125 v ac, and 1 1/2 hp, 250 v ac. **Unimax Switch Div., W. L. Maxson Corp., Ives Road, Wallingford, Conn.** B

Circle 684 on Page 19

Time-Delay Relay

1/2-oz unit can be
mounted in any position

No. E404 timing device has delay ranges from 0.1 to 10 sec, and maximum reset time is 10 mu sec. Weighing only 1/2 oz, unit is potted



in polyurethane foam and is hermetically sealed. It can be mounted in any position. Relay resists shock of 100 g for 11 millisecond, ± 1 millisecond, and acceleration of 100 g. Operating temperature is -65 to +85 C, continuous duty. Voltage ranges from 18 to 32 v dc. **Wheaton Engineering Corp., 920 Manchester Rd., Wheaton, Ill.** I

Circle 685 on Page 19

Shaded-Pole Motor

fractional-horsepower unit
is permanently lubricated

Type KSB33-frame, small, shaded-pole Unitized motor is a two-pole unit designed for such applications as domestic freezer evaporators, domestic refrigerator evaporators, electronic equipment fans, and other small fractional-horsepower component motor applications where long life without maintenance is required. Permanently lubricated



DYNAMIC DIFFERENCE

in hydraulic performance

Webster

"HC" SERIES POSITIVE DISPLACEMENT GEAR-TYPE PUMP

Tough, tenacious . . . Terratrak! When this powerful diesel dozer flexes its hydraulic muscles, things *move*! Just a touch on the control lever triggers the action . . . a Webster "HC" pump follows up with a surge of oil power to handle big loads *fast*.

This is just one application of the big capacity "HC" series. There are many more. On all types of heavy industrial and road building equipment it powers demanding hydraulic jobs with speed, stamina and reserve.

And, there are additional reasons engineers specify the "HC" series . . . they're compact, adapt easily to the product and job, dependable. That's why when you figure on Webster, it adds up to *the dynamic difference that pays!*

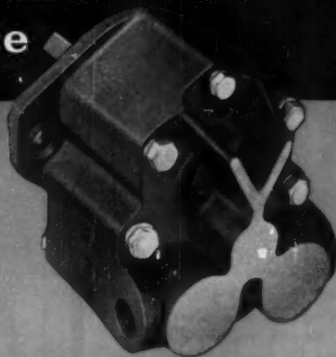
OIL HYDRAULICS DIVISION

WEBSTER



ELECTRIC

RACINE · WIS



"HC" SERIES POSITIVE DISPLACEMENT GEAR-TYPE PUMP

Shaft seal: lip type

Drive: direct, gear or belt

Capacity: 5 sizes, 5 - 17 gpm

Pressure: to 1500 psi

Operating speeds: to 2400 rpm

Porting: side (Std.) and (Opt.)

Valve: optional; internal relief,

adjustable 800 - 1500 psi

BULLETIN HY1 gives complete engineering characteristics — performance and installation data.

Call the man from Webster

... he's one of a staff of engineers specially trained in hydraulic application. He can help you solve special problems when hydraulics become a part of your design.



photo . . . courtesy J. I. Case Company, Racine, Wis.

Circle 518



Servospeed
HEART OF
AUTOMATION

**MODERN
ELECTRONIC
ENGINEERING
GIVES PRECISE
MOTOR SPEED
CONTROL**
1/100 — 10 H. P.

Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.

Servospeed
DIV. of ELECTRO-DEVICES, Inc.
4 Godwin Ave., Paterson, N. J.
ARMORY 4-8989

Circle 519 on Page 19

NEW PARTS AND MATERIALS



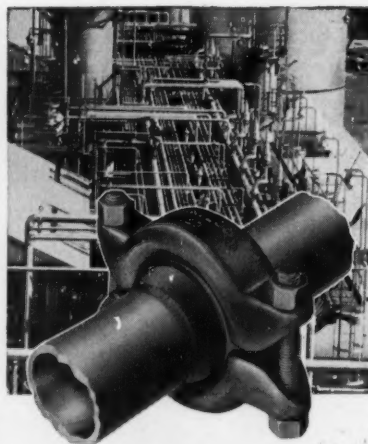
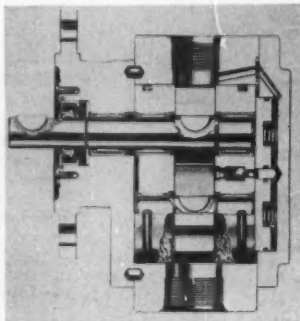
unit is rated from 1 to 20 millihorsepower, single-phase, 115 v, 60 cycle, 3000 rpm, open or enclosed. It is 2.2 in. wide and 2.66 in. high, with length varying with specific ratings. Two basic versions are available, one for horizontal-mounting applications which have only light axial end-thrust loads, and the second for all-angle mounting applications which require a motor to handle axial end-thrust loads exceeding free-end-play motor. Motor provides small size, light weight, high efficiency, and low current drain. General Electric Co., Schenectady 5, N. Y. C

Circle 686 on Page 19

Gear Pumps

for 3000 psi
constant pressure

Gear pumps deliver uniform flow regardless of variations in fluid viscosity or load, and are available with capacities of 5, 10, 15, or 30 gpm. They are intended for 3000 psi constant pressure and 4500 psi intermittent pressure service. Pressure-compensated pumps are light in weight, small in size, and have high pressure range. Needle bearings, contained in a pair of one-piece bearing blocks, will not misalign



GRAYLOC New Principle of Pipe Connections

Two-bolt GRAYLOC Pipe Connections introduce a new principle in pipe make-up. Its design makes it possible for GRAYLOC to withstand full vacuum, high external pressure and extreme internal pressure. Moreover, this design makes it possible to make up GRAYLOC Connections repeatedly with no wear or other damage to the connections.

The bolting carries no primary force from internal pressures. Two bolts serve only to pull the connection together through the wedging action of the clamp and the seal ring.

Flexible tapered lips of the seal ring are angled slightly less than the mating hub. This forms a line seal which is changed to a surface seal as the connection comes together and the lips deflect.

GRAYLOC has practical uses in any application where flanges are used. GRAYLOC is recommended where pressures are high or where you want savings in money, space, weight or time.

For additional information, write, wire or telephone Gray Tool Company.

GRAY
Tool Company
P. O. BOX 2291 HOUSTON, TEXAS
REpublic 4-1641 5903

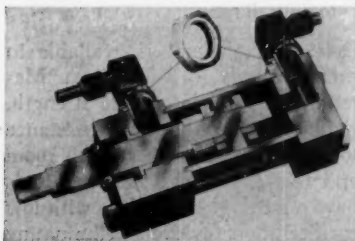
Circle 520 on Page 19

under loads, assuring precision alignment of both gears and needle bearings at all operating pressures. Rear floating-bearing block urged against gear faces by hydraulically actuated pistons automatically takes up wear and maintains zero end clearance. Actuating pistons are offset toward pressure side of pump and placed approximately opposite center of internal pressure to insure uniform wear over entire surface of wear plate. Superior Hydraulics Div., Superior Pipe Specialties Co., 15201 St. Clair Ave., Cleveland 10, Ohio. **F**

Circle 687 on Page 19

Power Cylinders

now incorporate
new port seals



All standard models of air and hydraulic cylinders, boosters, and accumulators are now available with new port seals that provide perfect sealing, speedy positioning, and complete protection from overtightening damage. Seals consist of hexagonal steel threaded nut with threaded Teflon sealing insert that is impervious to chemical or corrosive action of all hydraulic fluids, air, steam, water, gases, and practically all chemicals. Seals are of pressure-sealing type specified by JIC Standard H6.2.2. Miller Fluid Power Div., Flick-Reedy Corp., York and Thorndale Roads, Bensenville, Ill. **J**

Circle 688 on Page 19

Nonglare Light

for applications
requiring subdued light

Bolt-lite unit is available for illuminating instruments, instrument panels, control panels, and other applications such as aircraft, automotive, and electronics that require subdued nonglare illumination. Up-



Which is the MOST ECONOMICAL FORM OF PRODUCTION for your design?



* Ampco's one-source service will provide finished parts to your specifications.

You can get them all in an AMPCO METAL

Your Ampco field engineer is not limited to a single copper-base alloy or a single form, in making recommendations. He can be completely impartial, because Ampco supplies them all.

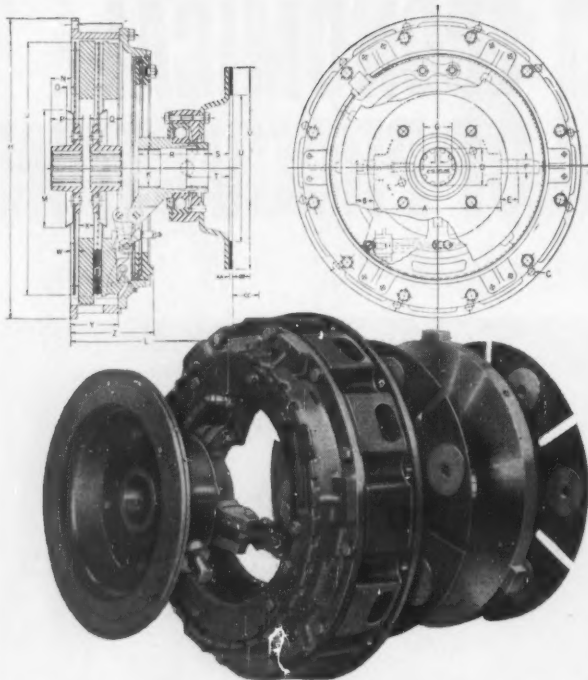
He helps you realize savings that are often substantial, by making best use of (1) Ampco's metallurgical know-how; (2) Ampco's extensive mechanical and production facilities; (3) new techniques and equipment developed through Ampco research.

Call in your Ampco field engineer. Write for bulletin.

Q-21

AMPCO METAL, INC., Dept. 30A, Milwaukee 46, Wis.
WEST COAST PLANT: BURBANK, CALIFORNIA • SOUTHWEST PLANT: GARLAND (DALLAS COUNTY), TEXAS

ROCKFORD



Greater Power With Less Size from a DOUBLE PLATE Clutch

This Heavy-Duty ROCKFORD Morlife CLUTCH, used in a large crawler-type tractor, provides more torque capacity than previous clutches of the same diameter. More service life and more heat resistance makes this clutch perfect for all heavy-duty type machines. A heavy-duty brake plate is mounted on the ball bearing type release sleeve. If you have a heavy-duty vehicle in the planning stage, it will pay you to learn about these and other advantages of this new clutch—before you design the drive line. A design study of your present drive lines might indicate advantages of using this Heavy-Duty ROCKFORD CLUTCH.



SEND FOR THIS HANDY BULLETIN

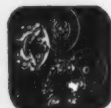
Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

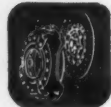
311 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

CLUTCHES



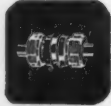
Small
Spring Loaded



Automotive
Spring Loaded



Heavy Duty
Spring Loaded



Oil or Dry
Multiple Disc



Heavy Duty
Over Center



Light
Over Center



Power
Take-Offs



Speed
Reducers



NEW PARTS AND MATERIALS



per and lower limits of light are controlled through the use of prisms, eliminating light spill-over and reducing eye strain. Unit is available in 6, 12, or 28-v models. Typical dimension is 1.5 in. over-all length with No. 10-32 stud mounting. Glar-Ban Corp., 108 Glar-Ban Bldg., 3807 Harlem Rd., Buffalo, N. Y.

Circle 689 on Page 17

Delrin Rods

are available in sizes
to 3 in. diam

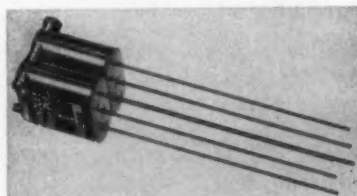
Delrin acetal resin is available in extruded rods to 3 in. diam. Material has excellent tensile strength, rigidity, fatigue life, and resistance to creep and solvents at both room and elevated temperatures. Rods have a hard, glossy surface with low coefficient of friction, eliminating slip-stick. They also possess exceptional dimensional stability, good abrasion resistance, and high fatigue endurance limit. Material can be blanked and punched to produce smooth, flat parts such as washers, grommets, actuator cams, and nonprecision gears. Garlock Packing Co., 441 Main St., Palmyra, N. Y.

Circle 690 on Page 19

Trimming Potentiometer

can be stacked to
ten in a row

Model 1W-STK trimming potentiometer is a stackable unit. Two to ten can be stacked in a row, firmly held together by a steel bolt and nut. Wire-wound potentiometer withstands 100 g acceleration and 50 g shock. Temperature range is



from -55 to 140 C with 1.3 w at 40 C. Small worm-gear adjustment, free of backlash, delivers high friction loading, and 360-deg wiper maintains setting under extreme temperature and vibration excursions. Inductive reactance is measurable at 900 kc. **Handley Inc.**, 2030 Colorado Ave., Santa Monica, Calif.

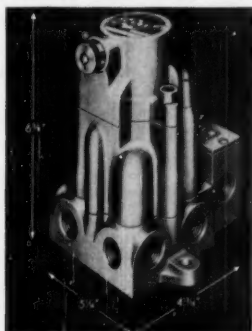
L

Circle 691 on Page 19

Air-Control Valve

can be replaced in
less than 30 sec

PDQ air-control valve can be completely removed by loosening two cap screws, twisting pilot cap, removing pilot cap and valve housing. Operation takes less than 30 sec. Valve has only two replacement



parts, poppet spindle-sleeve assembly and solenoid-pilot assembly, each of which is a self-contained unit. Repacking requires no tools, and takes less than 1 min. Weighing only 4 lb, valve is a full 1/2-in. NPT unit that flows 335 cfm with 100 psig initial pressure to atmosphere. Unit is available in 3/8, 1/2, and 3/4-in. tap sizes. **Hunt Valve Co.**, Salem, Ohio.

G

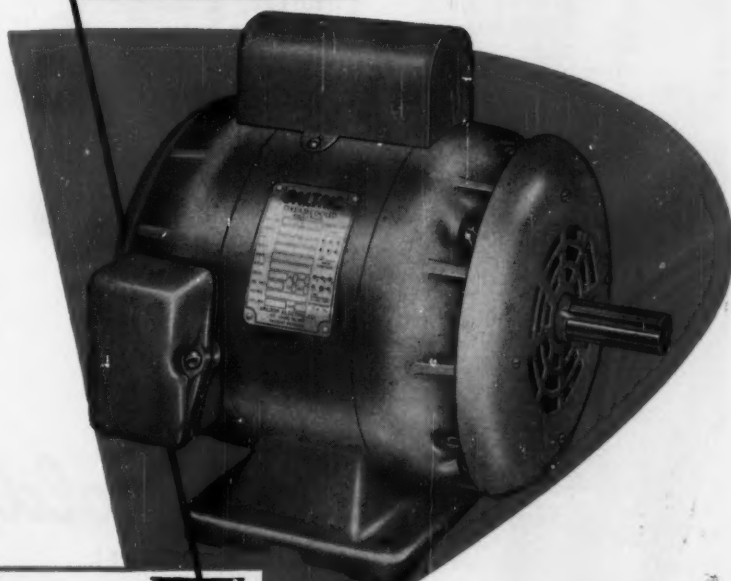
Circle 692 on Page 19

Reducer Couplings

for tubing of
any thickness

O-Ring Seal reducer couplings are available in a full range of sizes in stainless steel, cadmium-plated steel, or black phosphate and special finishes. Couplings, developed as a means of reducing or increasing tube size as is necessary at various points in many systems, consist of a standard fitting plus a reducer coupling with nut and split tapered

Specially designed with the APPLICATION in mind!



TYPICAL EQUIPMENT POWERED BEST BY BALDOR MOTORS

- Blowers
- ★
- Fans
- ★
- Ventilators
- ★
- Agriculture dryers,
cleaners, separators
- ★
- Conveyors
- ★
- Woodworking
machinery
- ★
- Abrasive saws
(masonry & steel)
- ★
- Pumps
- ★
- Compressors
- ★
- Machine tools

BALTRIC line of BALDOR motors

No guesswork here! Now you can stop fitting the machine to the motor.

Famous Baldor Streamcooled Motors featuring TEFC construction, are engineered and designed to fit *specific* applications—your guarantee of getting the *one right* motor that will deliver the power and performance to make your equipment operate at top efficiency.

There's a highly trained and experienced Baldor representative near you who will be happy to show you how this "tailored-to-the-job" type of engineering can help cut costs and improve the performance of your equipment. Contact him direct or write to . . .

BALDOR
ELECTRIC COMPANY
4349 Duncan Avenue • St. Louis 10, Missouri

Over 500 Authorized Sales & Service Distributors in U. S. A.

District Offices: Atlanta • Chicago • Cleveland • Dallas • Dayton • Des Moines • Detroit • Litchfield, Conn.
Los Angeles • Milwaukee • Minneapolis • New York • Kansas City, Mo.
Oakland • Philadelphia • Portland, Ore. • Syracuse



*the
true gauge
of
quality*

MicroRold[®] STAINLESS STEEL SHEET & STRIP

FIFTEEN YEARS AGO, we were the first stainless steel sheet producer to recognize the superiority of the Sendzimir Cold Reduction Process over conventional rolling equipment for exceptionally close tolerances.

Our equipment is such that tolerances can be held to as low as 3% (plus or minus), as compared to the A.I.S.I. maximum allowable variation of 10%. This "Thinness Control" means the ability to control decimal thickness with micro-accuracy, giving you more stainless area per ton or the equivalent area with less weight. It is this controlled accuracy and uniformity that directly relates to fabricating economies and satisfaction in the ultimate end use.

MicroRold Stainless Steel Sheet is available in widths up to 36" in gauges from .005 to .109, and in widths up to 48" from .010 to .109 in all commercial grades, finishes and tempers. MicroRold Strip can be supplied in widths up to 23½" in gauges from .010 to .109, and VERI-THIN Strip as thin as .0015 to .009 in all commercial strip finishes.

*Distributed by steel warehouses
throughout the world!*

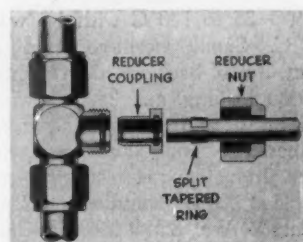


Send for your copy of "MicroRold Stainless Steel Handbook"

WASHINGTON STEEL CORPORATION

WOODLAND AVENUE • WASHINGTON, PENNSYLVANIA

NEW PARTS AND MATERIALS



ring. They eliminate the need of hex bushings, pipe threads, or metal-to-metal seals. Assemblies provide a dependable seal even under conditions of shock or vibration. Reducers are applicable to tubing of any thickness and can be disassembled and reassembled many times with all parts reusable. They can be used in unions, elbows, tees, crosses, and bulkhead connections, making possible line reductions on any leg. Lenz Co., Dept. N-75, 3301 Klepinger Rd., Dayton 1, Ohio. **G**

Circle 693 on Page 19

Printed-Circuit Laminate

has high
dielectric strength

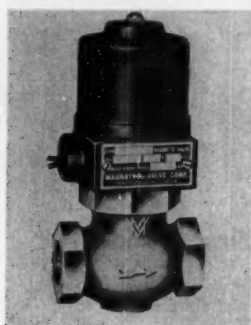
Kop-R-Klad high-temperature, high-dielectric-strength printed-circuit laminate is made with a new bonding method which does not employ a third material as an adhesive, nor does it require copper to be oxidized. Both conductor and insulating material remain pure and lose none of their innate properties. Peel strength of laminate is high. Material is available in 12 types, including copper bonded to Teflon, Teflon-glass, Kel-F, or FEP fluorocarbon. Laminate is furnished in sheets and/or continuous rolls, dependent upon type and size. W. S. Shamban & Co., 11617 W. Jefferson Blvd., Culver City, Calif. **L**

Circle 694 on Page 19

Solenoid-Operated Valve

for line pressures to 500 psi

Type L full-port, normally closed, solenoid-operated valve is for use in applications where fluid temperatures do not exceed 400 F and where line-pressure ratings are as high as 500 psi. Valve can be cleaned and operating mechanism replaced without removal of valve body from pipe line. Solenoid



coil has Class-H insulation for continuous-duty, high-heat service. Valve return spring is also heat resistant with moving parts allowing sufficient clearance to allow for thermal expansion. Magnatrol Valve Corp., Hawthorne, N. J. D

Circle 695 on Page 19

Switch and Light

are rated 2 amp inductive, 28 v dc

Moistureproof, double-pole, double-throw, pushbutton switch, WC1506, has over-all length of 1 5/8 in. with behind-the-panel depth of 7/8 in. Unit is available with various adapters, some of which are suitable for engraving up to 20 characters. SC1501 switchlight has an independent and isolated lamp circuit, and is available with 6, 14, or 28-v lamp. The 5/8-in. diam lens provides space for engraved legend. Over-all length of this unit is 2 3/8 in. with behind-the-panel depth of 1 1/32 in. Both units are rated at 2 amp inductive, 28 v dc. Hetherington Inc., 1420 Delmar Drive, Folcroft, Pa. E

Circle 696 on Page 19

Hydraulic Control Valve

for mobile equipment use

Multispool hydraulic control valve is controlled electrically by oil-immersed, dirtproof dc solenoids or optional ac solenoids that are prewired to plug-in type wiring connectors. For service with pressures to 2000 psi, and with nominal rating of 15 gpm, valve is offered in a three-spool size. It is designed specifically for mobile equipment use. Double A Products Co., Hydraulics Div., Brown & Sharpe Mfg. Co., Manchester, Mich. T

Circle 697 on Page 19

NEW Young 4-Pass SHELL and TUBE Heat Exchangers Cut Water Usage up to 75%



Typical Young 4-Pass Heat Exchanger used to cool hydraulic fluid in automation equipment

FULL LINE OF
LOW COST
HIGH PERFORMANCE
HEAT EXCHANGERS



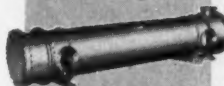
Stainless Steel
Single Pass



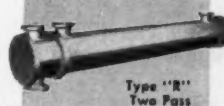
Stainless Steel
Multi-Pass



Type "R"
Single Pass



Type "RW"
Single or
Two Pass



Type "R"
Two Pass

Where critical water shortages, and high water rates are prime factors, specify the new Young 4-Pass water-conserving Heat Exchangers. The same amount of water in gpm through the Young 4-Pass Heat Exchanger would increase the velocity in ft./sec. four times, requiring just one-quarter the water flow of a single-pass heat exchanger to obtain the same velocity. Between 50 to 100 models are available from stock for immediate delivery. Write for Catalog No. 1258A.

MORE THAN 230 Standard Fixed and Removable Bundle MODELS IN STOCK

Whatever your heat exchanger requirements may be, there is a Young Heat Exchanger to meet the demands of every cooling, heating or condensing application. Over 230 standard units fit the operating requirements most frequently specified and are readily available.

Other units are available incorporating the use of cupro-nickel, muntz metal, naval bronze, stainless steel or any combination of metal required.

AIR-COOLED HEAT EXCHANGERS

Young designs and builds all types of Horizontal and Vertical Core Air-Cooled Heat Exchangers for cooling and temperature control of; oil, water, or gases, and for condensing vapors.

Write for catalogs describing the type you desire.

ideas for solving heat transfer problems are GOOD IDEAS

Young

YOUNG RADIATOR COMPANY DEPT. A-300

RACINE, WISCONSIN

PLANTS AT RACINE, WISCONSIN AND MATTOON, ILLINOIS

DON'T LET THE PRICE FOOL YOU!

Despite Their Lower Cost

**BROOK
A.C. MOTORS**

Give Outstanding Service

Anybody who knows motors will recognize that there is no finer motor than the Brook. These motors have established excellent service records in industry. Yet, they actually cost less!

Space age production methods and extensive distribution in 76 countries makes possible this better motor at lower cost. All standard enclosures. 1 to 600 H.P. Start saving now—look into Brook Motors at once. Write for literature and name of your dealer.

SINCE 1904



world's most respected motor

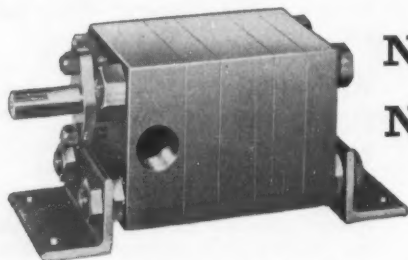
BROOK MOTOR CORPORATION

3302-04 W. Peterson Ave., Chicago 45, Ill.

Factory Representatives, Warehouses, Dealers, Service Stations, in Major Cities
In Canada: Brook Electric Motors of Canada Ltd., 250 University Ave., Toronto, Ont.

Circle 526 on Page 19

Proven in thousands of installations



**NORTHERN
NITRALLOY
PUMPS**

Northern Nitralloy Pumps are noted for their ability to handle difficult pumping assignments. They're able to do so because they are built to tolerances of extreme accuracy from a variety of metals. Rugged design plus precision construction equals years of good service.

Pump sections and parts are interchangeable and can be made from Nitralloy, ni resist, cast iron, steel, stainless steel, bronze, aluminum and other metals. This permits designing pumps for virtually any application.

Northern Pumps are available in capacities from 1/4 to 146 gpm at pressures up to 2,000 psi. For free catalog and engineering data, write today.

Northern Ordnance Incorporated

Subsidiary of NORTHERN PUMP COMPANY

Minneapolis 21, Minnesota

Circle 527 on Page 19

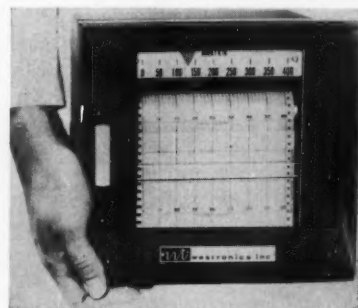
ENGINEERING
DEPARTMENT

EQUIPMENT

Strip-Chart Recorder

miniature unit uses
5-in. strip chart

Model M5 miniature multipoint recorder is a recording potentiometer which allows plotting of 12 variables on a 5-in. calibrated chart width by scanning and sampling. Each variable is identified at its position on chart by a number and a point, printing with multiple or single colors. Six different colors are available on standard model. Instrument is available with 12 points and standard printing rate of 5 sec per point. Stepper selector switch



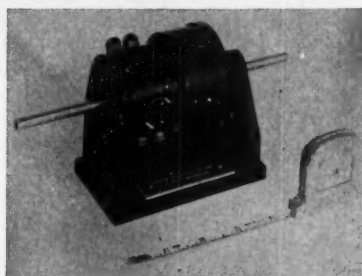
can be mounted remotely, eliminating need of numerous thermocouple extension wires from measuring point to recorder. Spans are available with thermocouple or linear millivolt calibrations over wide range. Minimum practical span is 1 mv full scale. **Westronics Inc.**, 3605 McCart, Ft. Worth, Tex. P

Circle 698 on Page 19

Miniature Torque Pickups

have sensitivities of 50,
100, 250 oz-in. full scale

Line of miniature torque pickups is available for a variety of low-torque measurements in laboratory testing and product development. Typical sensitivities of standard models are 50, 100, and 250 oz-in. full scale, with useful speed ranges to 10,000 rpm. Electrical sensitivity is 2 mv. Shaft mounts a 120-ohm, full-



bridge strain gage. Solid-silver slip rings and silver-graphite brushes hold thermoelectric voltages below 2 mv, peak to peak, at full speed of 10,000 rpm. Length, excluding shaft extensions, is $4\frac{3}{4}$ in., width is 3 in., and base-to-shaft height is $2\frac{1}{4}$ in. Lebow Associates, 941 W. Warren, Detroit, Mich. T

Circle 699 on Page 19

Nonreproducible Paper

is translucent,
dry-developed diazo type

Nonreproducible blue-line intermediate paper, Transblue 200T, is a translucent, dry-developed diazo paper coated with light blue-line sensitization which is not reproducible on other diazo type materials. Blue line serves only as a legible guide and will not reproduce. Any opaque image or line subsequently drawn in over blue line will reproduce. Paper is well suited for color separations, visual-aid materials, geological maps, medical training charts, designing wiring diagrams, and lifting out details from assembly drawings. Line drawings can be made from photographic copy by printing negative on Transblue and using outlines of negative image for guides. Ozalid Div., General Aniline & Film Corp., 38 Corliss Lane, Johnson City, N. Y. N

Circle 700 on Page 19

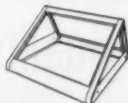
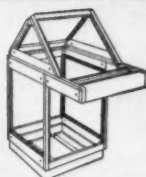
X-Y Recorder

has integral ac-dc input

X-Y recorder, Model 2D Autograf, has an integral ac-dc input and built-in X-axis time base. Unit operates directly from a transducer and eliminates need for an extra ac converter. Dc ranges provide accuracy and resolution of better than 0.2 per cent. Input range is 7.5 mv to 150 v on X axis and 5 mv

A record in precision and reliability with 6 and 8 channel recording systems housed in...

**EMCOR[®]
CABINETS**



CHOOSE FROM
OVER 600 BASIC FRAME
ARRANGEMENTS



Sloped-Front Console-mounted 6 & 8 Channel Recording System

Console-mounted recording systems manufactured by BRUSH INSTRUMENTS, Cleveland, Ohio, and housed in EMCOR Cabinets serve as readout stations for telemetry, testing, computer, ground control and other data processing systems.

EMCOR Cabinets offer a compact, versatile and functional housing for industrial or military recording systems. A combination of "human engineering" in cabinet design by EMCOR and instrumentation by Brush Instruments affords simplicity of operation. All controls are within easy reach and visibility of the operator. The flexibility, versatility and structural capabilities of over 600 basic frames in the EMCOR MODULAR ENCLOSURE SYSTEM bring advanced engineering and "imagineering" to meet your packaging requirements. Write for details.

Condensed Version of Catalog 106
available upon request.



Originators of the Modular Enclosure System

ELGIN METALFORMERS CORP.
630 CONGDON, DEPT. 1226 • ELGIN, ILLINOIS

*Registered Trademark of Elgin Metalformers Corporation

DEVELOPMENT ENGINEERING GROUP

A dynamic, rapidly expanding manufacturer in the field of xerography (physical photography based on solid-state and electrostatic phenomena) has outstanding growth opportunities for:

SECTION LEADER

M.E., 8 to 12 years' experience in design and development of complex electro-mechanical devices. Knowledge of military design requirements essential.

PROJECT AND SENIOR PROJECT ENGINEERS

M.E., 6 to 12 years' experience in complex electro-mechanical devices. Knowledge of military specifications and requirements desirable.

ASSOCIATE ENGINEERS

M.E. or E.E., 1 to 4 years' product experience in electro-mechanical machines and equipment.

PRODUCT ENGINEERS

M.E., E.E., or I.E., 3 to 8 years' experience in electro-mechanical product design for manufacturing.

CHECKERS AND SENIOR CHECKERS

Six to eight years' experience in electro-mechanical devices—at least one year in checking.

• Kindly send resume and salary requirements to:

FRED A. WETTERINGS
Industrial Relations Division
HALOID XEROX INC.

P. O. Box 1540, Rochester 3, New York

**HALOID
XEROX®**

ENGINEERING DEPT. EQUIPMENT



to 100 v on Y axis. X-axis time base (5 steps) is 7.5 to 750 sec. Input resistance is 200,000 ohms per v. Recorder provides zero offset and a vacuum paper hold-down. Pen speed is 20 ips for each axis. Accessories are available to increase versatility of unit. F. L. Moseley Co., 409 N. Fair Oaks Ave., Pasadena, Calif.

Circle 701 on Page 19

Display Oscillograph

monitors temperature, strain, pressure, velocity

Model 201 Profile Monitor provides an accurate, easily interpreted, visual display of any phenomena measurable by electrical output.

Typically monitored are temperature, pressure, strain, and velocity. With accommodations for as many as 90 inputs, unit displays one of



these phenomena or any combination having comparable electrical outputs. Wide selection of available full-scale sensitivities is provided. Advanced Technology Laboratories, Div., American-Standard, 369 Whisman Rd., Mountain View, Calif.

Circle 702 on Page 19

High-Vacuum Pumps

have capacity of
5 to 10 liters per sec

Suited for general laboratory use, Series 150 UlteVac electronic high-

STAKTUBE ROLL FILE SYSTEM

All steel-encased cabinets with steel-rimmed tubes for easy-to-find, safe print storage. Complete with tubes: 4 ID's, 8 lengths, 32 sizes. Files bolt together for stacking to any height. With locks if desired.



9-TUBE
4 1/4" ID



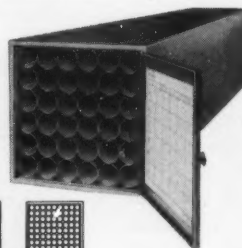
16-TUBE
3 3/8" ID



36-TUBE
2 3/4" ID



81-TUBE
1 3/4" ID



Flat Files



Staktube
Roll Files



Stacor-Matic Tables



Tracing Boards
& Tables



Portable
Roll Files



4-Post
Drafting
Tables



Pedestal
Drawing
Tables

SPECIFY STACOR

the line that's engineered for
lifetime quality service

Stay with STACOR—all down the line . . . files thru tables. You're investing in efficiency and economy when you specify STACOR Lifetime Quality equipment for all drafting room needs.

Write TODAY for New Complete Catalog.

STACOR EQUIPMENT CO.



Manufacturers of Lifetime Quality, Drafting Equipment
for School & Industry

273 Emmet St., Newark 5, N. J.—Bigelow 2-6600

Warehouse Stocks in: Boston, Detroit, Hartford, Los Angeles, Montreal, Philadelphia, Saint John, N. B., San Francisco, Toronto, Washington, D. C.

vacuum pumps weigh 13 lb and have dimensions of $6\frac{1}{4} \times 7\frac{3}{4} \times 5$ in. They produce clean ultimate vacuums below 10^{-6} mm Hg. Model 150E contains a replaceable multi-filament evaporator, permitting injection of additional titanium. Pumping speed for this model is 10 liters per sec, and for standard units, 5 liters per sec. Roughing vacuum of 15 to 20 mu is required only for starting. Compact, all-metal coupling with rotatable flanges permits



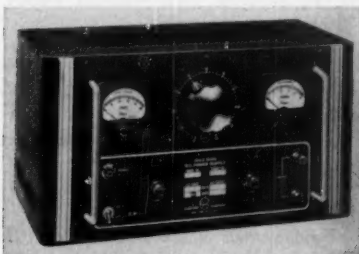
any desired orientation of pump. Ultek Corp., 920 Commercial St., Palo Alto, Calif. M

Circle 703 on Page 19

Power Supply

has rms ripple
of 100 mv

Model KM75B direct-current power supply has ac ripple reduced by 80 per cent to extend usefulness to transistorized-circuit operation and development. Rms ripple is limited to a maximum of 100 mv throughout range of zero to 32 v dc and zero to 5 amp. Input to power supply is 115 v ac, 60 cycles, single phase. Voltage regulation has also been reduced to provide maximum change of 3 v when load current changes from $\frac{1}{2}$ to 5 amp. Cabinet



(shown) and rack-mounting models are available. Opad Electric Co., 43 Walker St., New York 13, N. Y. D

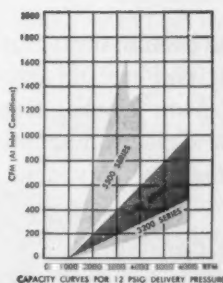
Circle 704 on Page 19



new
m-d
engine
mounted

blowers

weigh only 625 lbs. Provide 400 SCFM
continuous air flow



M-D answers the need for lightweight pneumatic units for vacuum or high pressure systems. Only 625 lbs. total weight of blower and engine. Dependable M-D units generate 15 PSIG of continuous air flow or up to 18 PSIG in surges. Ideal for mobile applications. M-D muffler packs mean quiet operation.

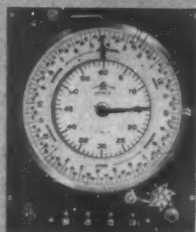
M-D blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 22 production models range from 50 to 4,000 CFM, pressures to 15 PSIG single, 70 PSIG multi-stage.



For full information write
M-D BLOWERS, INC., RACINE, WISCONSIN

A SUBSIDIARY OF  MIEHLE-GOSS-DEXTER, INC.

ZENITH TIMERS

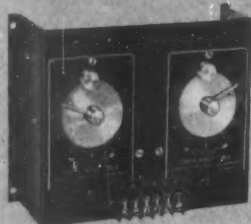


Program Clocks

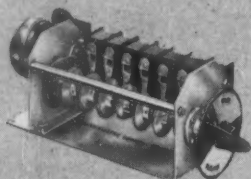
Interval
Timers



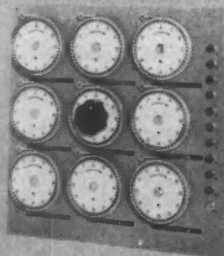
Time
Delay
Timers



Automatic Reset Timers



Multi-Circuit Cycle Timers



Master Programmers

A Wide Range of Special and Standard Types —FAST DELIVERY

Choose the timing control you require from the versatile Zenith line. You'll get prompt engineering and delivery on specials, *immediate delivery on standard controls.*

Quality, reliability and fair price—these you can be sure of when you specify or order Zenith.

- Program Clocks
- Time Switches
- Interval Timers
- Time Delay Timers
- Automatic Reset Timers
- Multi-Circuit Cycle Timers
- Percentage Timers
- Impulse Timers

Zenith has been manufacturing industrial timing controls, program clocks, time switches and electromagnetic controls for over 35 years.

**Write for Catalog
18-AT. See classi-
fied phone direc-
tory for your local
distributor.**



ZENITH ELECTRIC CO.

149 WEST WALTON ST. • CHICAGO 10, ILL.

THE ENGINEER'S

Library

Recent Books

Amino Resins. By John F. Blais; 220 pages, 5 by 7½ in., clothbound; published by and available from Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y., \$4.95 per copy.

Although this book is primarily for chemical engineers, design engineers may find it helpful in providing information concerning properties and applications of melamine and urea plastics. Topics include compression - molding, adhesive, laminating, and surface-coating applications.

An Introduction to the Mechanics of Solids. Edited by Stephen H. Crandall and Norman C. Dahl, Massachusetts Institute of Technology; 444 pages, 6 by 9¼ in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from MACHINE DESIGN, \$8.50 per copy postpaid.

Mechanics of rigid and deformable solids in equilibrium is covered. After fundamental principles of mechanics are reviewed, advanced notions concerning forces and moments transmitted by slender members, stress and strain, torsion, bending stresses, and buckling are discussed.

Creative Discussion. By R. L. Cortright and G. L. Hinds; 303 pages, 5½ by 8½ in., clothbound; published by The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; available from MACHINE DESIGN, \$6.00 per copy postpaid.

Industrial leadership conferences, brainstorming, role-playing, and problem-solving are covered. Creative participation in all discussion situations is stressed.

Fundamentals of Electronics. By F. H. Mitchell; 260 pages, 6¼ by 9¼ in., clothbound; published by Addison-Wesley Publishing Co. Inc., Reading, Mass.; available from MACHINE DESIGN, \$6.50 per copy.

Text includes dc and ac circuit

theory, electron emission, diodes, and multielectrode tubes. Amplifiers, special-purpose tubes, and control circuits are also covered. In this second edition, resonance (series and parallel) has been expanded, and new treatments of grounded-grid amplifiers and electron ballistics are presented.

Association Publications

General Session on Powder Metallurgy. 105 pages, 8 by 9 3/4 in., paperbound; available from Metal Powder Industries Federation, 60 East 42nd St., New York 17, N. Y.; \$4.00 per copy.

Transactions include 13 papers presented at the 15th annual meeting of the Metal Powder Industries Federation. Detailed information on new developments in powder metallurgy includes compacting metal powder into continuous sections, improved properties of brass powder-metallurgy parts, and a unique method for bonding cemented carbide to steel by diffusion techniques. Fundamental theory, processing machinery, and production techniques are discussed.

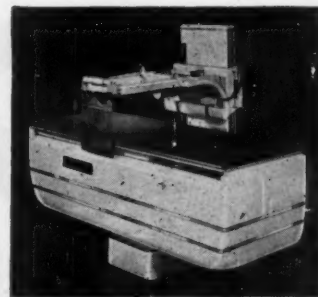
ASTE Collected Papers: Volume 50—Book 2. 292 pages, 8 1/2 by 11 in., paperbound; available from American Society of Tool Engineers, 10700 Puritan Ave., Detroit 38, Mich.; \$10.00 per copy.

Twenty-four papers discuss product engineering, fabricating processes, manufacturing planning and control, tooling design, metal-working principles, metal forming, engineering materials, quality control, and manufacturing management. This book is primarily for tool and manufacturing engineers, but design engineers may find it helpful in providing insight into tooling and production.

Tentative Recommended Practice for Variable Area Meters, ISA-RP 16.1.2.3. 6 pages, 8 1/2 by 11 in., paperbound, stapled; available from Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.; \$0.75 per copy.

Covered are glass-tube, metal-tube, and extension-type glass-tube rotameters. Terminology, dimensions, and safety practices are discussed.

Winsmith speed reducers specified for Westinghouse Fluoradex X-ray tables . . .



Fluoradex "150"
Radiographic-
Fluoroscopic Table.
Horizontal position.

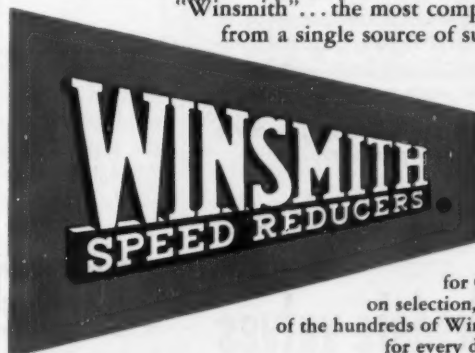
SELECTION BASED ON

- Compactness
- Efficiency
- Quiet Operation

TABLE BASE, REAR VIEW

Table is tilted by precision linkage mounted on a multiple sprocket, chain-driven through a compact Winsmith Differential Reducer.

Fluoradex Radiographic-Fluoroscopic Tables are precision instruments of high strength and flexibility, combined with safe, quiet operation. For table tilt motion in keeping with this high-quality design, Westinghouse specified a Winsmith Differential Reducer with 108:1 reduction. Reasons for the Westinghouse choice of Winsmith—compact design, efficiency and quiet operation—are the same reasons so many other leading manufacturers also specify "Winsmith"... the most complete line of speed reducers from a single source of supply.



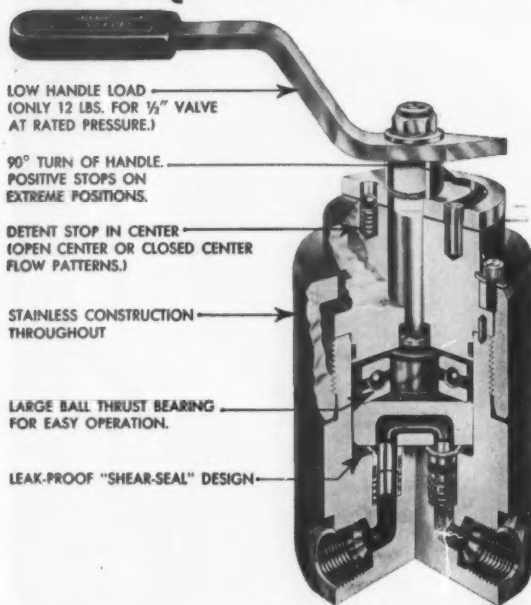
WRITE TODAY

for Catalog No. 155 for full details on selection, operation and maintenance of the hundreds of Winsmith types and sizes for every drive application.

WINSMITH, INC. 16 Elton Street, Springville, (Erie County), N. Y.

10,000 P.S.I.

4 WAY VALVE FOR LIQUIDS OR GASES



This new four-way valve series comes in pipe sizes from $\frac{1}{4}$ to 1 inch, but may be obtained with tube, AND 10050, or any preferred special high pressure connection. It will withstand surges of up to 15,000 P.S.I. without damage to the valve's sealing qualities. It is designed for a burst pressure of 30,000 P.S.I.

No port to port leakage occurs in the detented positions because of the exclusive "Shear-Seal" design.

Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation.

Of course, there is no external shaft leakage, because the pressure is confined to the flow passages.



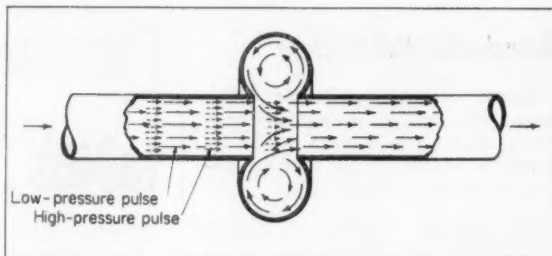
CONTROL VALVE
DIVISION

Write for Catalog 59-60
Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

NOTEWORTHY Patents

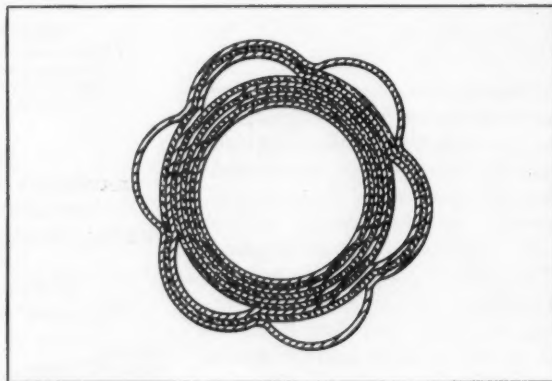
Gas-Flow Pulsation Damper



A pulsating gas stream is smoothed by vortical flow of gases in a toroidal chamber surrounding the gas tube. A portion of each high-pressure pulse is fed into the chamber which acts to increase the length of the flow path. These portions then join with succeeding low-pressure pulses in the main gas stream to provide a smoother gas flow. Patent 2,910,830 assigned to General Electric Co., by Donald R. White.

Multiple-Passage Pipe

High thermal conductivity is provided between passages of a fluid line made of metal-foil laminate. Layers of metal foil are bonded with adhesive. The foil can be



selected to provide corrosion resistance and thermal conductivity as required. For corrosion resistance, only the exposed layer need be of resistant material. Patent 2,914,091 assigned to Foil Process Corp., Van Nuys, Calif., by James F. Barnes and Herman I. Silversher.

Built-In Ball-Bearing Seal

Short axial length in a ball-bearing and seal assembly is made possible by using a part of the bearing raceway to house a sealing unit. A carbon sleeve and a ring magnet seal the face of the inner bearing race. An

Wanted: Engineers

with an interest in writing

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on MACHINE DESIGN, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications. Age: 25 to 35.

If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested

in any job experience or training in:

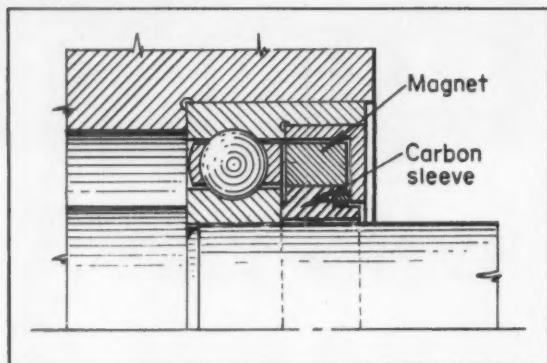
- Mechanical drives, controls, systems
- Mechanical components, assemblies
- Electrical or electronic drives, controls, systems
- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

MACHINE DESIGN

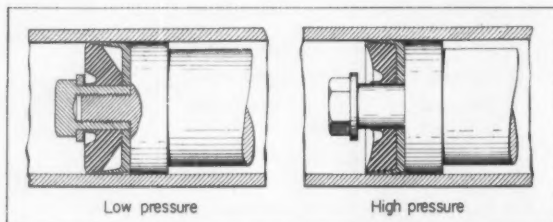
NOTEWORTHY PATENTS



O-ring seals the outer race. Patent 2,913,289 assigned to Magnetic Seal Corp., by Robert Stevenson.

Two-Stage Hydraulic Seal

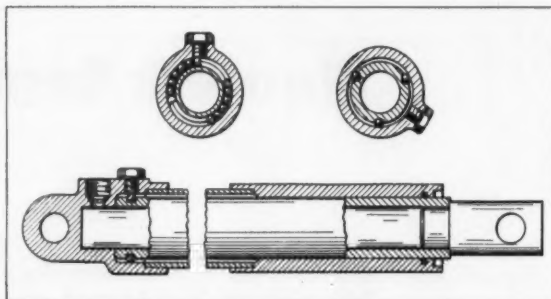
Effective sealing of a hydraulic piston at both low and high pressures is provided by a cup of hard sealing



material combined with a tapered plug of soft material. At low pressure, the soft material provides a sealing lip with low-friction drag. At high pressure, the plug withdraws from the cylinder wall and forces the cup of hard material against the wall. Patent 2,914,369 assigned to Blackhawk Mfg. Co., West Allis, Wis., by Dennis J. Hayman.

Ball-Bearing Piston Guide

Ball bearings, retained by a groove in the piston of a hydraulic cylinder, reduce friction forces and serve as a stop for the inner end of the piston. The balls may



also be retained in individual recesses in the piston. Matching grooves in the cylindrical wall would then provide for controlled rotation of the piston during its stroke. Patent 2,915,046 assigned to Bendix Aviation Corp., South Bend, Ind., by Lester J. Larsen and Charles A. L. Ruhl.

Engineers and Draftsmen ... For Your Fact File ...

MINIMUM PERFORMANCE STANDARDS FOR TRACK DRAFTING MACHINES

The Right
Drafting Machine
for every drafting need

- ★ TRACMASTER
- ★ BOARDMASTER
- ★ DESK-TOPPER
- ★ Duraline Scales

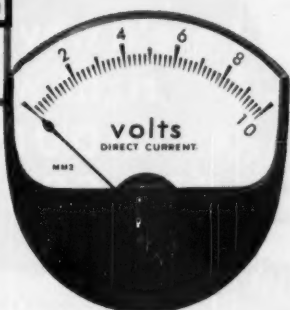


a. Tracking Straightness, maximum deviation	e. Maximum Horizontal Backlash, 4# Load
.010	.015
b. Tracking Squareness, .010	f. Maximum Vertical Backlash, 4# Load
c. Maximum Horizontal Deflection, 1# Load	.010
.010	g. Maximum Horizontal Stiction
d. Maximum Vertical Deflection, 1# Load	1.5#
.010	h. Maximum Vertical Stiction
	1.5#

Only the Universal TRACMASTER Meets these Minimum Standards...

Write for Free Engineering Test Report and Literature on Complete Universal Line of Drafting Machines and Scales.

UNIVERSAL DRAFTING MACHINE CORP. 7960 LORAIN AVE. • CLEVELAND 2, OHIO



MEDALIST* meters

Combine increased readability with attractive color styling. ASA/MIL 1½", 2½" and 3½" mounting. Up to 50% longer scale in same space as conventional types. Standard and special colors. Bulletin on request. Marion Instrument Division, Minneapolis-Honeywell Regulator Co., Manchester, N.H., U.S.A. In Canada, Honeywell Controls Limited, Toronto 17, Ontario.

*T.M. Reg. U.S. Pat. Off. U.S. & Foreign Patents Copyright © 1959, Marion

75 YEARS
PIONEERING THE FUTURE



First in Control
SINCE 1899

Circle 542 on Page 19



adjustable enclosed LIMIT SWITCH

Roller-arm actuator continuously adjustable through 240° in each of eight 45° indexing positions. Sealed against moisture, dust, and oil.

KABP2HB-5

Write for data sheet.

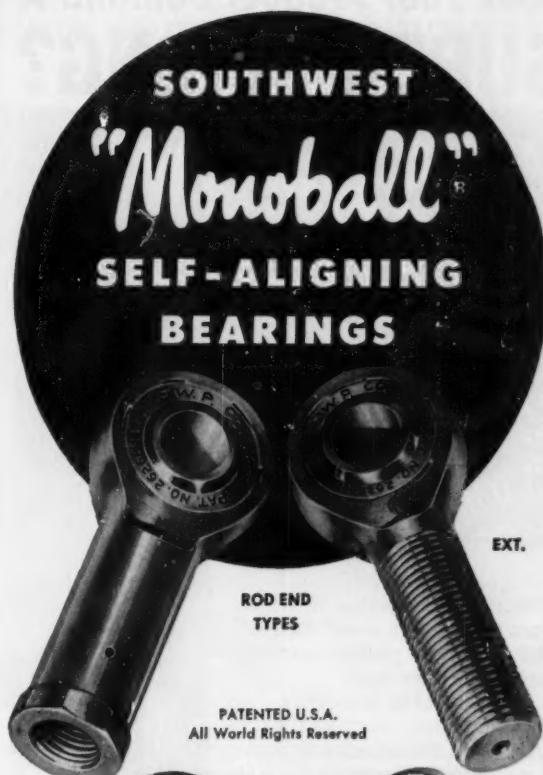
ELECTRICAL RATINGS

20 amp. 125/250/480 volts a-c
¾ HP 125 v. a-c; 1½ HP 250 v. a-c.

UNIMAX SWITCH

Division, The W. L. Marion Corporation
IVES ROAD, WALLINGFORD, CONNECTICUT

Circle 543 on Page 19



ROD END
TYPES

PATENTED U.S.A.
All World Rights Reserved

PLAIN TYPES

CHARACTERISTICS

ANALYSIS

- 1 Stainless Steel Ball and Race
- 2 Chrome Alloy Steel Ball and Race
- 3 Bronze Race and Chrome Steel Ball

RECOMMENDED USE

For types operating under high temperature (800-1200 degrees F.).
For types operating under high radial ultimate loads (3000-893,000 lbs.).
For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for Engineering Manual No. 551. Address Dept. MD-M60.

SOUTHWEST PRODUCTS CO.

1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

Circle 544 on Page 19

207

Does Your Product Demand A SUPER SPRING?

NEW

SANDVIK

2R25

STAINLESS SPRINGS

*Give 5 To 10 Times
Longer Performance*

This newest addition to the Sandvik spring line is made from a premium steel for applications where performance demand outranks cost.

The steel is Sandvik's own 2R25 stainless...a special extra-tough and ultra-resilient grade. It enables the springs to withstand 5 to 10 times the windings that ordinary carbon steel springs can take. At the same time, it can endure the corrosive attacks of varying atmospheres.

Sandvik 2R25 springs are being supplied in either spiral or Sandvik's exclusive cross-curved types. Write or phone for further information on these super springs or on Sandvik's broad line of standard quality springs. Free literature, case history files and specific spring design assistance are available to you.



SANDVIK STEEL, INC.

Fair Lawn, New Jersey

Tel. 5WArthmore 7-6200

In New York City:
ALgonquin 5-2200

Cleveland • Chicago
Detroit • Los Angeles



design, purchasing, production men . . .

here's why you're
right with
**MOORE
SET'SCREWS**



Headless Slotted



Square Head



Socket Head

Design — there's a Moore Set Screw exactly right to meet your specs. On new developments or on hard-to-solve problems we have experienced men to supply the answers.

Purchasing — you can depend on us, without question, to meet your schedules. Your reputation is backed up by our reputation of 80 years of dependable service.

Production — our inspection guarantees conformity and uniformity. Your assembly lines run smoothly and quality control is simplified.

Moore Set Screws simplify design, purchasing, production.
Send for detailed price catalog.

**MOORE
SET SCREWS**

George W. Moore, Inc.

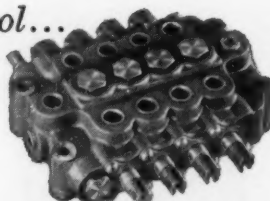
since 1880

93 Beaver St., Waltham 54, Mass.

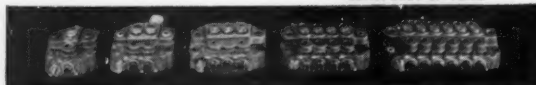
Circle 546 on Page 19

*So Much Control...
So Little Space*

HUSCO HYDRAULIC VALVES



HUSCO 4-Plunger, 45 G.P.M.
Series 3200-SP Valve



- In ONE to SIX Plunger Designs
- For up to FOUR Control Positions
- Capacities from 3 to 185 G.P.M.

Other HUSCO features include:

- Power-Saving Pilot-Operated Relief Valve
- Short Plunger Movement for more accurate control — at minimum effort.
- Check Valve Controlled circuits — Conventional or Parallel.
- Compact, precision-built for minimum space.
- Over 120 Standard Models — for unlimited modification to your needs.

Check HUSCO First for Hydraulic Control. Write for your copy of HUSCO'S "House of Ideas in Control Engineering" — or design assistance on your needs.

**HYDRAULIC UNIT
SPECIALTIES CO.**

PUMPS • VALVES • CYLINDERS
P. O. Box 257-M, Waukesha, Wisconsin
West Coast Representatives
EASTMAN PACIFIC CO., Los Angeles, Calif.
ROY BOBBS AIR-DRAULIC CO., Portland, Ore.



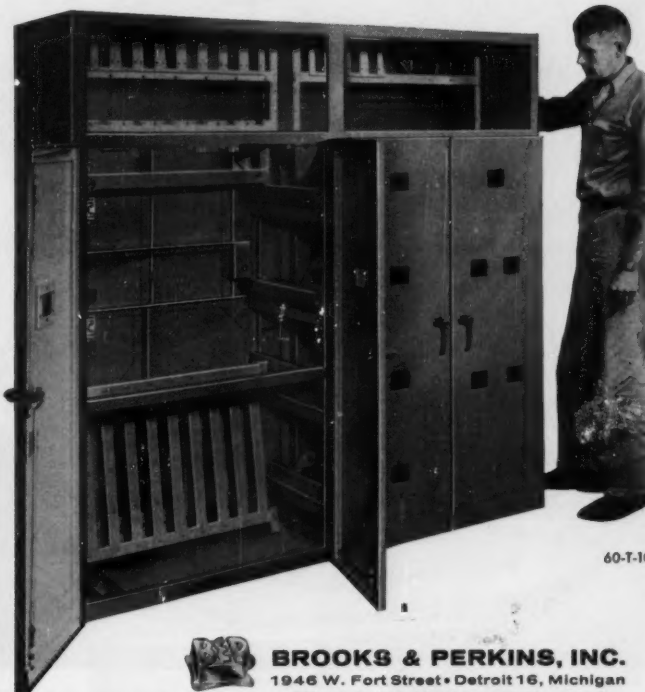
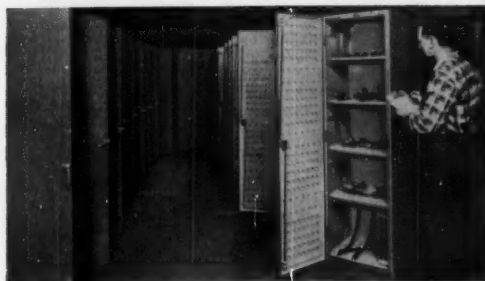
B & P Precision Cabinets and Consoles for Missile System Ground Support Equipment

Cabinets and consoles for electronic and fire control equipment are important elements of ground support equipment in every missile and radar system.

For many years B & P has made cabinets for Nike and other missile systems. These precision cabinets, of magnesium or aluminum, are made as arc-welded assemblies. Special techniques have been developed to prevent distortion during welding. Every cabinet is stress-relieved after welding.

Of the thousands of cabinets and consoles built by B & P, all have been held to close dimensional precision.

When you need lightweight electronic cabinets and consoles, think first of B & P, the most experienced builder of precision light metal electronic ground support equipment cabinets. For more complete details, write to B & P, Detroit.

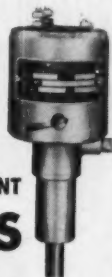


BROOKS & PERKINS, INC.
1946 W. Fort Street • Detroit 16, Michigan
Offices in Washington and New York

Circle 548 on Page 19

SPEED SENSITIVE SWITCHES

1, 2 & 3 ELEMENT



OVERSPEED

One S.P.D.T. switch to trip at speeds between 500 and 6,000 RPM.

OVER AND UNDERSPEEDS

Two S.P.D.T. switches to trip at two different speeds between 300 and 6,000 RPM.

UNDERSPEED

One S.P.D.T. switch to trip at speeds as low as 250 RPM. Maximum operating speed 5,000 RPM.

OVER INTERMEDIATE AND UNDERSPEED

Three S.P.D.T. switches to trip at three different speeds between 350 and 6,000 RPM.

EXPLOSION PROOF AVAILABLE

The switches listed above are available with explosion proof containers that meet all of the specifications of Class I, Group D, explosion proof equipment.

For further information ask for Bulletin 504 and 504 A.

SYNCHRO-START PRODUCTS, INC.
8151 N. RIDGEWAY AVENUE, SKOKIE, ILLINOIS

Circle 549 on Page 19

Designing a Conveyor?

FLAT-FLEX WIRE BELT

A PRODUCTION BOOSTER FOR ANY INDUSTRIAL PROCESS

- Minimum Contact with Materials
- Flow thru Mesh
- Positive Gear Drive
- Easy to Install, Guide, Clean, Maintain
- Straight Runs or Turns
- Special Alloys for Higher Temperatures

WIRE BELT COMPANY OF AMERICA
1 River Street, Winchester, Mass.

Circle 550 on Page 19

209

A lot at stake?



depend on

A⁺Adlake

mercury to mercury relays

Surgical lighting control, X-ray control, wherever foolproof performance is important, depend on relays that can't burn, pit or stick. Depend on mercury-to-mercury contacts of Adlake, rated A⁺ for design and construction. The Adams & Westlake Company, Elkhart, Indiana. Original and Largest Manufacturer of Plunger-type Relays.

Illustrated—1101 type with normally closed contacts.

SEND TODAY FOR FREE CATALOG



Circle 551 on Page 19

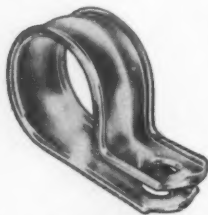
Weckesser



Black Nylon for high temperature and other severe service conditions.

CABLE CLAMPS

A STYLE AND SIZE FOR EVERY CABLE FASTENING REQUIREMENT



of economical Ethyl-Cellulose for maximum service at minimum cost.

Weckesser Cable Clamps offer superior insulating properties, high strength, light weight . . . with *no* rust or corrosion.

Non-circular shapes also available. Immediate delivery from on-hand stocks.

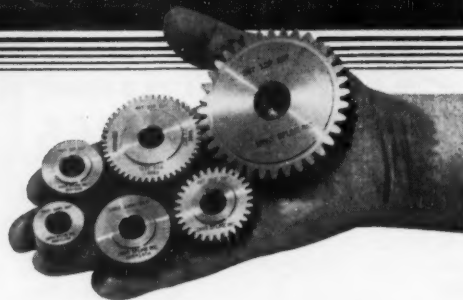
WRITE TODAY FOR FREE SAMPLES AND PRICE SHEET

Weckesser COMPANY

5715 Northwest Highway • Chicago 46, Ill.

INVO MASTER SPUR GEARS

ULTRA-HIGH PRECISION



Immediate delivery from stock

- .0002 Maximum Composite Error
- 20 Pitch and Finer
- 14½° and 20° Pressure Angles
- Hardened and Ground Tool Steel

INVO SPLINE, INC.

P. O. BOX 25

HAZEL PARK, MICH.

PHONE SLocum 7-8840

SEND FOR STOCK LIST

What IS a GOOD DRY, FILM LUBRICANT APPLICATION

CASE HISTORY 768

Large, automatic water valves for city water mains. EverLube eliminates sticking and other malfunctions. The plug, seat, screw, operating lever and bearing were EverLubed.



FACTS... not fantastic claims to assist you in design lubrication



EverLube Design Handbook

This design handbook is yours free... written to provide valuable assistance to the design engineer... explains the good and the poor applications for dry lubricants.

Plus FREE SAMPLE CASE

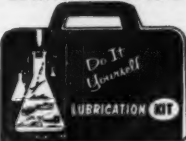
A handy case containing a sample of EverLube dry lubricant—try doing-it-yourself.

Mfg. under Pat. Nos. 2,470,136 and 2,534,406.

Custom shops in principal cities

EverLube Corp.

6940 Farndale Ave.
No. Hollywood, Calif.



Circle 554 on Page 19

The ROTARY UNION* Outlasts all other Rotating Joints

The Rotary Union's patented construction, with its optically flat mechanical seal, automatically adjusts to pressure ranges... eliminates mechanical maintenance and adjustments. Gives smooth sealing and unmatched service on all types of rotating heating or cooling equipment. Ball bearings reduce wear and power consumption.

A Precision Mechanical Seal

- Self-Aligning
- Self-Adjusting
- Pipe Sizes 1/4" thru 3"

"WHERE Good Connections COUNT"

*Trade Name Patented



PERFECTING SERVICE CO.

332 Atandt Ave.

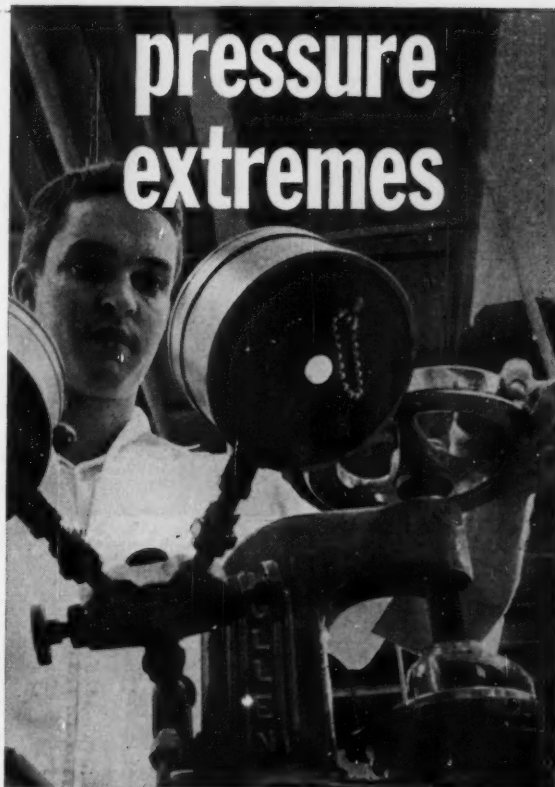
Charlotte, N.C.

Baltimore—Buffalo—Camden, N.J.—Chicago—Cleveland—Los Angeles
New York—Providence—Hamilton, Ont.—Montreal—Toronto

Circle 555 on Page 19

you don't worry about

pressure extremes



The Mullen Burst Test, being run here at our lab in Buena Vista, Virginia, is the yardstick to determine maximum resistance to burst to make certain the material conforms to specifications.

with Reeves Vulcan Diaphragms

One of the numerous inspections in our system of quality control is the Mullen Burst Test. This inspection is used on every roll of coated fabric before it is shipped or made into diaphragms.

From the gross psi readings of this test, we can assure you that Reeves Vulcan Diaphragms will safely withstand the pressures listed in our specifications.

You name the application—we'll supply the right diaphragm or diaphragm material for your specific needs. For prompt action, call or write us today.

REEVES

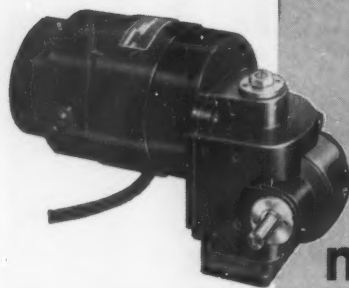


**VULCAN
RUBBER PRODUCT**

Reeves Brothers, Inc., Vulcan Rubber Products Div.
1071 Avenue of the Americas, New York 18, N.Y.

Circle 556 on Page 19

211



RAE motors

engineered to meet your needs

Careful analysis and testing of your product together with experienced RAE Engineers is your assurance of the best motor for the job. RAE offers outstanding service and quality in a large variety of motors in voltages up to 250, and up to 1/2 H.P. (higher for intermittent duty) with many gear head motor combinations. Let us put our years of motor building experience to work for you.

- AC/DC Universal
- DC Shunt wound
- DC Series wound
- DC Compound wound
- Gear Reduction Motors
- Governor Controlled Motors
- Motors for Rheostat Control

Send for the "RAE" service sheet. It will help you supply the data necessary for recommendations and prices.

Rae MOTOR CORP.

2009 Kewaunee St. • Racine, Wis.

Circle 557 on Page 19

Lepel

HIGH FREQUENCY

Induction

HEATING

**HARDENING
SOLDERING
ANNEALING
MELTING
BRAZING**

LEPEL Electronic Tube
GENERATORS — 1 KW; 2 1/2 KW;
5 KW; 10 KW; 20 KW; 30 KW; 50 KW;
75 KW; 100 KW.

LEPEL Spark Gap Converters
2 KW; 4 KW; 7 1/2 KW; 15 KW; 30 KW.

WRITE FOR THE NEW LEPEL CATALOG . . . 36 illustrated pages
packed with valuable information.

All Lepel equipment is certified to comply with the
requirements of the Federal Communications Commission.

LEPEL HIGH FREQUENCY LABORATORIES, INC.
55th STREET and 37th AVENUE, WOODSIDE 77, NEW YORK CITY, N. Y.

212

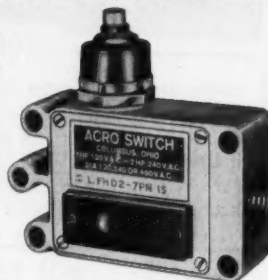
Circle 559 on Page 19

BUYING BETTER DIE CASTINGS — No. 2

Paramount Die Castings protect new ACRO-LITE visual indicator switch...

Acro-Lite metal-enclosed visual indicator switch. Electrical rating: 21 amperes, 2 H.P. — up to 75 amperes inrush current.

Paramount aluminum die castings make up the sturdy protective housing of the new Acro-Lite switch manufactured by Acro Division of the Robertshaw-Fulton Controls Co. Casting design permits quick, easy assembly of the switch and housing. Castings require no machining except for tapping.



PARAMOUNT zinc, aluminum and magnesium die castings can help solve your product problems.

It will pay you to investigate the complete die casting service available at Paramount Die Casting Co. Paramount's designers, sales engineers, and modern tooling and production facilities offer you an ideal die casting source.



Three complete plants—two in St. Joseph, Michigan, one in Seymour, Indiana.

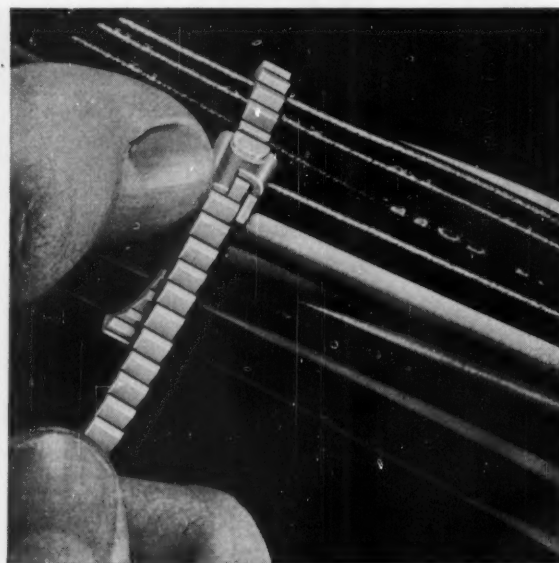
SEND FOR THIS HELPFUL BROCHURE



PARAMOUNT Die Casting Co.

(A Subsidiary of TALON, INC.) ST. JOSEPH, MICHIGAN

Circle 558 on Page 19



SECURE WIRE BUNDLES IN SECONDS!

Simply pull this modern self-locking nylon strap around your wire bundle, cut off the excess, and you have a positive-holding installation. No tying, no knots, no hitches to come loose with Bund-L-Tite*. It's the fastest, surest, most permanent way to secure wire bundles! Proved in aircraft and missiles under extreme loads, Bund-L-Tite* straps are made of tough, light-weight DuPont zytel, which meets MIL-P-17091. Write for free literature.

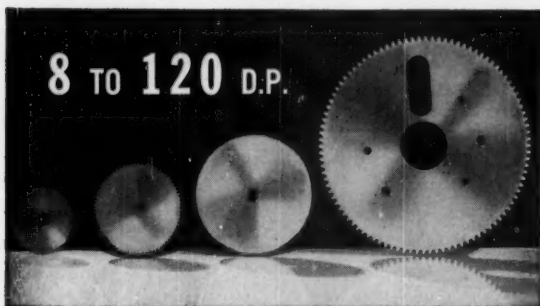
DAKOTA

Manufacturer of Cab-L-Tite clamps.
ENGINEERING, INC.

4315 Sepulveda Blvd., Culver City, California

*Trade Mark

Circle 560 on Page 19



LONG LIST OF STOCK GEAR DIES OFFERS YOU BIG SAVINGS!

ACCURATE STAMPED GEARS by WINZELER are BIG savers of time and money. Single stampings are laminated to wide faces at savings up to 60%! Further economies are made possible by a BIG range of stock Dies. Modern new plant, methods, and equipment now greatly increase production speed, efficiency and economy! Send blue prints. Tell us about your needs today. No obligation.

SEND FOR...

New list of WINZELER-made stock Gear Dies. Ask for it on company letterhead, please!



WINZELER MANUFACTURING & TOOL CO.
7355 W. WILSON AVENUE • CHICAGO 31, ILLINOIS

Circle 561 on Page 19

Here's
data
on the

New

DIAL HEAD AGASTAT® time/delay/relays

These relays have recently been re-designed—improved in performance and appearance. So you'll want up-to-date specs.

This free folder gives complete details on all models. In it you'll find operating specs, timing ranges, contact capacities, dimensions, diagrams of contact and terminal arrangements, and data on mounting and installation accessories.

For your copy, write: Dept. A34-128.

AGA ELASTIC STOP NUT CORPORATION OF AMERICA
Elizabeth, New Jersey

Circle 562 on Page 19



to protect customer goodwill with...

S.S. White PLASTIC PLUGS AND CAPS

For mere pennies you can insure customer goodwill... by protecting your products with S.S. White plastic plugs and caps. Not a chance of damaged threads, dirt, moisture, or leakage during shipping or handling. And... the extremely simple removal of S.S. White plugs and caps will demonstrably save him money and production time. They come off rapidly by hand... no shreds, no residue left in the part.

And don't forget... their rapid installation and low cost mean savings in your plant too!

Two lines to choose from:

The quality line—of rigid acetate... tough, non-brittle, impervious to petroleum-base oils and greases, outstanding impact strength.

The economy line—of elastoplastic vinylite... a "non-slip grip" for rapid installation and removal, a "stay-put fit."

WRITE FOR FREE BULLETIN
(P5708) and samples
(please state size and type)

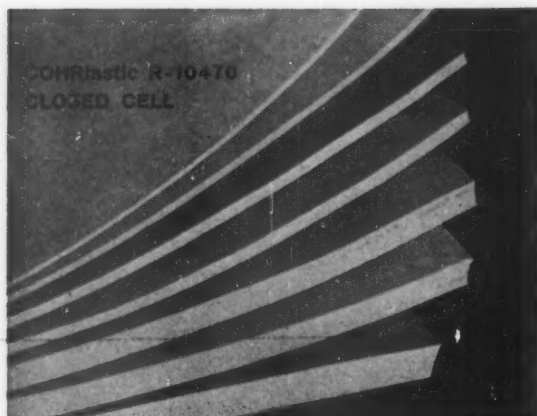
S.S. White PLASTICS
DIVISION

Dept. 4-P • 10 East 40th Street • New York 16, N. Y.



Circle 563 on Page 19

213



Silicone Sponge Rubber

flexible at temperatures — 100°F to 500°F

COHRLastic R-10470 has a dense, uniform, non-absorbing closed cell structure, highly suitable for soft gasketing, vibration dampening, fairing strips, pads, cushions and other applications where resiliency at extreme temperatures is required. It may be bonded to metals, plastics, fabrics or silicone rubber. Possesses superior compression set resistance, excellent dielectric properties, immunity to aging, ozone and weather hardening. Available from stock in 24" x 24" sheets — 1/16" through 1/2". Special sizes and extruded shapes made to order.

FREE SAMPLES and folder — write, phone or use inquiry service.

CHR PRODUCTS: COHRLastic Aircraft Products — seals, coated fabrics, and ducts; COHRLastic Silicone Rubber Products — molding; and extrusions, sheets and sponge; Temp-R-Tape — pressure sensitive, thermal curing Teflon and silicone tapes; Allied Products — COHRLastic silicone cements and conductive gasketing.

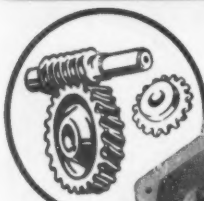
CHR CONNECTICUT HARD RUBBER

Main Office: New Haven 9, Connecticut

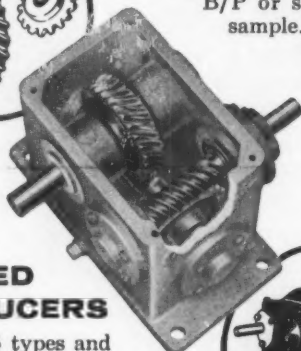
Circle 564 on Page 19

From PRECISION GEARS To ACCURATE SPEED REDUCERS

Abart Meets Any Industrial Need



GEARS—any type... any material... custom cut to specifications. Send B/P or specs for sample. Request bulletin.



SPEED REDUCERS

Over 75 types and sizes... fractional to over 400 hp., ratios to 10,000 to 1. Ask for information packed catalog.

Prompt Quotations • Quick Delivery • Write Today!

ABART GEAR and MACHINE CO.

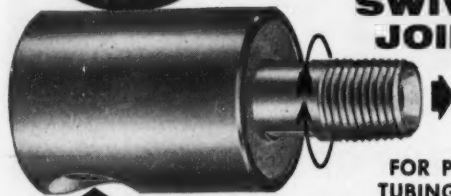
4821 WEST 16th STREET • CHICAGO 50, ILLINOIS

Here's How to Make Hose Work Better, Last Longer!

BARCO

LOW COST, BALL BEARING

SWIVEL JOINT



FOR PIPING, TUBING, HOSE

For Hydraulic or Pneumatic Service

Here is the new BARCO SINGLE PLANE SWIVEL JOINT that swivels in one plane only. Ideal for use as a swivel connector:

- **Key to Better Engineering!** Small, light, inexpensive. Very low torque under pressure. Neat, space-saving installations. Easy to position lines accurately.
- **Many Uses:** (1) To make piping or tubing movable, flexible! (2) As swivel connectors on hose to eliminate torsional working stresses and long radius bends. Longer hose life! Shorter lengths required!
- **Sealed, Unitized Construction.** Built with ball-bearings. O-ring seal. Choice of styles; sizes 1/4", 3/8", 1/2", 3/4". For service to 2,000 psi, —20° to 225°F. Other types available for higher ratings. Ask for Catalog Sheet 406.

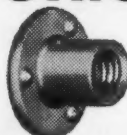
BARCO MANUFACTURING COMPANY

506B Hough Street

Barrington, Illinois

Circle 565 on Page 19

OHIO WELD NUTS



RH NUT

Thread Size 6-32 to 3/8-16



WF NUT

Thread Size 6-32 to 3/8-16



SF NUT

Thread Size 5/16-18 to 1/2-13



WW NUT

Thread Size 6-32 to 3/8-16

OHIO flanged weld nuts provide extra-long thread engagement and are ideal for assemblies requiring strong primary fasteners. They can also serve as spacers or bearing surfaces where required.

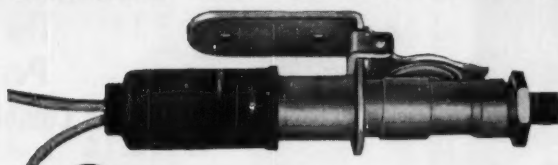
Samples and information furnished upon request.



Primary Fastener in Fastener Assemblies

THE OHIO NUT AND BOLT CO.
38 FIRST STREET BERE, OHIO

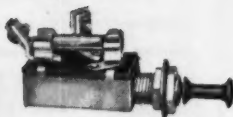
COLE-HERSEE *Switches & Connectors*



No. 1281 Heavy Duty Polarized
Two Pole Electrical Connector
(Insulated or Grounded)



No. 9524 Combination
Rotary Ignition
& Light Switch



No. 5053 Push Pull
Fused Light Switch

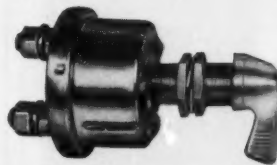


No. DL-5 Dash Lamp



No. 9522 Key
Operated Ignition
& Light Switch

Plastic-Coated Solenoid
Completely Waterproofed
Non-Breakable
Intermittent Duty Solenoid



Master Disconnect Switches
S.P.S.T. D.P.S.T.
(Extra Heavy Capacity)

BUILT UP TO A STANDARD — NOT DOWN TO A PRICE

COLE-HERSEE



COLE-HERSEE CO.

Over 40 Years of Consistent Quality Products

20 OLD COLONY AVENUE, BOSTON 27, MASS.

Circle 568 on Page 19

*Only ONE Torque Wrench
can be accurately used
with . . .*

**EXTENSIONS and
ADAPTERS**

It is mechanically impossible to use any Torque Wrench with adapters or extensions (with accuracy) unless that Torque Wrench has a positive, built-in, fixed load position.

This essential factor of accuracy, misunderstood or ignored in the design and manufacture of some torque tools, can completely defeat their purpose.

**PATENTED
PIVOTED HANDLE
FIXES LOAD POSITION**



Write for Torque Manual

with formulae tables and explanations for correct use of adapters and extensions.

PA **STURTEVANT CO.**
ADDISON **QUALITY** ILLINOIS

Circle 569 on Page 19

SAVE TIME

WITH KAMLOK QUICK COUPLERS



CUT YOUR MAINTENANCE COSTS

Save production time by replacing hose and pipe connections with Kamlok Quick Couplers. Used wherever hose and pipe connections are periodically uncoupled. Fast . . . Safe . . . Sure. No tools needed. Just fit together and pull the cam arms down. Lock securely in place. Leakproof gasket cannot fall out. All Kamloks 100% master gauged for complete interchangeability.

KAMLOKS are available from stock in bronze, aluminum, stainless steel, monel and semi-steel from 1/2" through 6" sizes. 39 different styles to choose from. Specials to fit your needs. Get full detailed information.

Send for Handbook F-10R

OPW-JORDAN

6013 WIEHE ROAD
CINCINNATI 13, OHIO

Circle 570 on Page 19

215

Get Easier, More Accurate Cylinder Speed Control

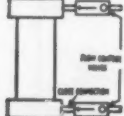


2,000 (brass
or aluminum)
and 5,000 (steel) p.s.i.

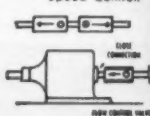
Pneu-Trol Valves combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to seat, requiring only a slight differential pressure to fully open or close it. Check Valve and Needle Valve incorporate single function features of Flow Control Valve. All valves available in 5 female pipe sizes — $\frac{1}{8}$ " to $\frac{3}{4}$ ". Valve bodies are made from brass, aluminum, steel or stainless steel. Attractive Prices — Immediate Delivery.

Write for Illustrated Circular and Price List.

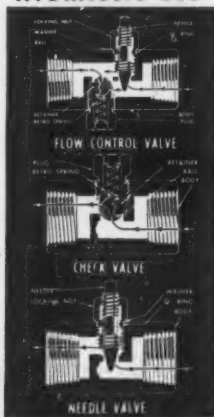
Inlet speed control for
Double Acting Cylinder.



Single Acting
Cylinder
Speed Control.



with
Pneu-Trol®
VALVES
IN AIR OR
HYDRAULIC USE

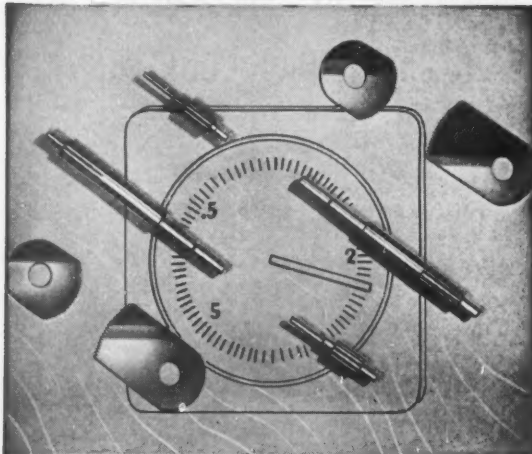


2925 GRANT STREET
BELLWOOD (Chicago Suburb) ILLINOIS

Circle 571 on Page 19

20 TO 200 D.P.

SEND YOUR PRINTS FOR QUOTATION



SPURS • HELICALS • WORM AND WORM GEARS
STRAIGHT BEVELS • LEAD SCREWS • RATCHETS
CLUSTER GEARS • RACKS • INTERNALS • ODD SHAPES

THE *Finest* IN GEARS

Beaver Gear Works Inc.

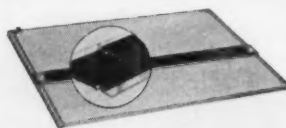
1031 PARMELE ST.

ROCKFORD, ILLINOIS

216

Circle 573 on Page 19

MAYLINE



The Best Possible Combination

A Mayline Straightedge and a Mayline table. Mayline straightedges are made from moisture resistant black satin laminated phenolic plastic. Transparent edges are crystal clear. Available in 30" to 96" lengths. Straightedges completely described in Folder S-15.

These fine straightedges attached to the May-O-Matic table make an incomparable combination. The May-O-Matic top is adjustable for height positioning and required angle of drawing position. It is available in 10 combinations. This amazing table explained in detail in Folder S-22. Send for both folders today.

MAYLINE CO., INC.

601 No. Commerce St.
Sheboygan, Wisconsin



MAYLINE

Circle 572 on Page 19

This Compact FUNK Unit SAVED Space



On this Jaeger concrete mixer, a FUNK-designed double right angle drive provides perfect alignment and positive chain adjustment. Mounted vertically on the "unitized" front trunnion stand, FUNK's unit takes up only a fraction of the space normally used in such applications.

Just one example of how FUNK MODULAR POWER UNITS may be combined in an unlimited number of arrangements — without special engineering costs.

Let FUNK solve your power transmission problem.

FUNK MFG. CO.

Box 577-F,
Coffeyville, Kan.

Circle 574 on Page 19

18-8 and 316

STAR STAINLESS SOCKET HEAD CAP SCREWS

Smooth and Knurled Types, Coarse, or Fine Thread. Sizes 0.80 and Up. Splined and Flat Head, Nylock and Socket Set Screws

RIGHT OFF THE SHELF®

This is just one line of Star's stock of stainless steel fastenings listed in our 1960 Catalog. STAINLESS STEEL 300 & 400 Series

- BOLTS & NUTS • WASHERS
- PINS • AN & MS FASTENERS
- HINGES

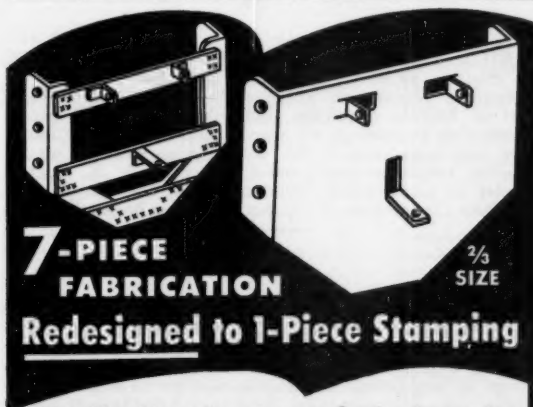
Send for YOUR Catalog today, request on letterhead please.



STAR STAINLESS SCREW CO.

658 Union Blvd., Paterson 2, N. J.
Phone: CLIFFORD 6-2300
Direct New York phone: Wisconsin 7-6310
Direct Philadelphia phone: WALnut 5-3660

Circle 575 on Page 19



Considerable costs were saved, plus improving appearance, by redesigning this seven-piece fabricated frame to a greatly simplified one-piece stamping. Spotwelding was eliminated. Exact duplication was achieved.

Got a fabrication problem? Chances are it can be solved with short-run stampings using the D-R method of utilizing temporary tooling. Send your print and/or sample, plus quantity, for prompt quotation. No obligation.

Bulletin F185 explains this highly efficient, specialized technique for cutting the work load and costs of metal fabricators. Send for it today.

DAYTON ROGERS
Manufacturing Company

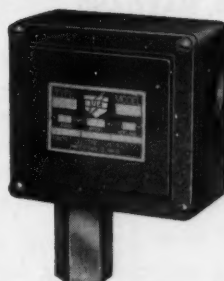
MINNEAPOLIS 7C, MINNESOTA

Circle 576 on Page 19

UNITED ELECTRIC Multi-Purpose PRESSURE CONTROLS

J7 | J40

► Enclosed-TYPE J7



► Skeleton-TYPE J40

These controls are compact, precision-built, rugged and inexpensive. Type J7 is ideal for controlling air, gas or liquid pressures up to 500 psi . . . Type J40 for pressures up to 250 psi.

Adjustable Pressure Ranges	J7 . . . various models cover ranges between limits of 0 and 500 psi J40 . . . various models cover ranges between limits of 0 and 250 psi
Switch Ratings	15 amps or 20 amps at 115 or 230 volts A.C., also D.C. switches upon specification
Switch Types	N.C., N.O., or Double throw, no neutral position
Electrical Connections	J7 . . . screw type terminals on switch standard J40 . . . solder type terminals on switch standard
On-Off Switch Differential	Fixed and uniform throughout specified range is standard
Mounting	J7 . . . 1/4" NPT female, brass fitting standard J40 . . . 1/8" NPT male, brass fitting standard
Variations	Design variations are available upon specification
Applications	On industrial equipment and engine applications . . . marine, aircraft or special purpose

Although UNITED ELECTRIC offers a complete line of temperature, pressure and vacuum controls . . . UR application engineers specialize in solving unique problems.

Send for full particulars today. Bulletins available upon request. Type J7 . . . Bulletin No. 5-7,

Type J40 . . . Bulletin No. 5-9



United Electric Controls
COMPANY

91 SCHOOL STREET, WATERTOWN, MASS.

Circle 577 on Page 19

STRESS ANALYST

ADVANCED ROCKET
RESEARCH AND DEVELOPMENT

HERCULES POWDER COMPANY
ALLEGANY BALLISTICS LABORATORY
CUMBERLAND, MARYLAND

Applicants should have graduate degree or equivalent experience in fields of (1) Pressure Vessel Analysis, (2) Composite Structure Analysis and (3) Plastic-Elastic Behavior of Materials. Familiarity with Shock and Vibration Analysis helpful but not a requirement.

The work is varied and challenging for persons having the ability to generate and direct testing programs and will lead to increased supervisory responsibilities.

Submit resume with full particulars to:

Mr. W. D. LINKENHOKER
HERCULES POWDER COMPANY
ALLEGANY BALLISTICS LABORATORY
BOX 210
CUMBERLAND, MARYLAND

Circle 578 on Page 19

ENGINEERS AVAILABLE OR WANTED

WANTED: Mechanical Engineers—All Levels. Top Company in automatic machinery field is looking for permanent additions to its mechanical engineering staff. Openings exist at all levels of experience. **THE CHALLENGE:** The Company has embarked upon a program of replacing all designs in its product line during the next few years as well as expanding lines in accordance with established plans. Emphasis is placed upon good theoretical design, backed by excellent development lab facilities rather than "cut and try". **THE PRODUCTS:** Medium weight, high speed, automatic machinery of wide variety. Machinery is used world-wide—commercial rather than military. Our machinery is the leader in each of its several fields. **THE COMPANY:** Medium size—50 years in business—1000 employees. It is the leader in its fields. Progressive management is young, aggressive and local. The Company considers engineering to be its real product. It is situated in a beautiful suburban New England area famous for educational facilities and excellent living conditions. **THE JOB:** The men chosen will be graduate engineers, preferably mechanical, with from one to ten years of experience in the field of automatic machinery and high speed, complex mechanisms. Emphasis is placed on "doing" experience in these fields with specific abilities in motion analysis, kinematics, dynamics and stress analysis. Challenging assignments are commensurate with the individual's experience and he is encouraged to grow. **THE REMUNERATION:** Salary levels are competitive with large metropolitan areas and benefit plans are excellent. **PLUS,** the satisfaction of working with a strong, engineering-minded management that can move quickly and surely to bring creations to reality. Send resumes in complete confidence to Box 962, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

ENGINEERS AVAILABLE OR WANTED

AVAILABLE: Mechanical Design Engineer in southern California with 20 years of experience and military clearance to develop that project in his own facility where quiet development is desirable. Resume furnished on request to company president or chief engineering officer. Address: Box 963, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: MACHINE DESIGNER. Must have at least 10 years of responsible heavy machine design experience, preferably in the steel producing field, including Sintering Machine Design. Immediate opening at our Cleveland Office. Send detailed resume and photo to G. Victor Hopkins, ARTHUR G. McKEE & CO. 2300 Chester Avenue, Cleveland 1, Ohio.

WANTED: Booming manufacturer of compressed air products needs engineer with managerial abilities and product design experience. Live in Colorado; new building, pleasant working conditions, fringe benefits—Salary open. Write, include resume of experience and salary requirements. Employment Department, 800 West 9th Avenue, Denver 4, Colorado.

WANTED: Engineer—Mechanical Power Transmission. We can offer an excellent opportunity for advancement to an outstanding Mechanical Engineer in design and development of flexible couplings and other mechanical power transmission equipment. We want a man who has initiative, ideas and experience in this field. Please write listing experience, education and present salary to: A. W. Pomper, Director of Engineering, Waldron-Hartig, Division of Midland-Ross Corporation, P. O. Box 791, New Brunswick, N. J.

WANTED: Project Engineer. If you have experience in machine design and know the field of paper converting, you can turn your ideas into results at Waldron. You will take charge of interesting, challenging design projects and supervise competent personnel. Your responsibility will extend from establishing or interpreting the initial specifications to successful operation of the equipment in the field. Please write describing experience, education, salary requirements to A. W. Pomper, Director of Engineering, Waldron-Hartig, Division of Midland Ross Corporation, P. O. Box 791, New Brunswick, N. J.

WANTED: Senior Design Engineer. Excellent opportunity for a Senior Design Engineer in the challenging field of Mechanical Development for a Graduate Engineer who can assume the full responsibilities for the design and development of special machines and mechanical equipment. Must exercise ingenuity and creative thinking in deriving solutions to assigned projects. Long term opportunities with an expanding pharmaceutical firm offering a broad program of employee benefits and excellent working conditions. Send complete resume, including salary requirements to Box 959, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Advertising Index

Abart Gear and Machine Co.	214
Adams & Westlake Co., The	210
Aeroquip Corporation	167
A/G'A Division, Elastic Stop Nut Corporation of America	213
Airborne Accessories Corporation	96
Allegheny Ludlum Steel Corporation	91
Allis-Chalmers, General Products Division	108
Allis, Louis, Co.	92, 93
American Brass Co., The, Anaconda Metal Hose Division	5
American Machine & Foundry Co., Potter & Brumfield Division	171
Ampco Metal, Inc.	193
Anaconda Metal Hose Division, The American Brass Co.	5
Automatic Switch Co.	Inside Front Cover
Automatic Timing and Controls, Inc.	44
Automotive Gear Division, Eaton Manufacturing Co.	16
Auto-Ponants, Inc.	216
Baldor Electric Co.	195
Barco Manufacturing Co.	214
Barden Corporation, The	177
Barksdale Valves, Control Valve Division	204
Beaver Gear Works, Inc.	216
Bellows Co., The, Division of International Basic Economy Corporation	77
Bethlehem Steel Co.	82
Bijur Lubricating Corporation	45
Bishop, J., & Co., Platinum Works, Tubular Products Division	76
Borg-Warner Corporation, Pasco Products Division	49
Borg-Warner Corporation, Rockford Clutch Division	194
Brad Foote Gear Works, Inc.	165
Bridgeport Brass Co.	81
Brook Motor Corporation	198
Brooks & Perkins, Inc.	209
Browning Manufacturing Co.	179
Burdry, Omaton Division	101
Carter Controls, Inc.	27
Chicago Rawhide Manufacturing Co., Oil Seal Division	21
Clare, C. P., & Co.	64, 65
Cleveland Worm & Gear Co., The, Speed Variator Division	Inside Back Cover
Cole-Hersee Co.	215
Commercial Filters Corporation	24
Connecticut Hard Rubber	214
Cramer Controls Corporation	74
Crane Packing Co.	39
Crofts U.S.A., Inc.	188
Cutler-Hammer, Inc.	Back Cover
Dakota Engineering, Inc.	212
Dayton Rogers Manufacturing Co.	217
Dodge Steel Co.	62
Duff-Norton Co.	190
Du Pont, E. I., de Nemours & Co., Inc., 53, 54, 95	
Durez Plastics Division, Hooker Chemical Corporation	51
Durkee-Alwood Co.	75
Eastman Chemical Products, Inc., Chemicals Division	172
Eaton Manufacturing Co., Automotive Gear Division	16
Elastic Stop Nut Corporation of America, A/G'A Division	213
Electro Devices, Inc., Servospeed Division	192
Elgin Metalformers Corporation	199
Eriez Manufacturing Co.	180
EverLube Corporation	211
Exalco Manufacturing Co.	164
Fellows Gear Shaper Co., The	86
Ferguson Machine Corporation	184
Funk Mfg. Co.	216
Garlock Packing Co., The, Plastics Division	97, 163
Gates Rubber Co., The	83

General Electric Co.	99
General Industries Co., The	175
General Motors Corporation, New Departure Division	11
General Steel Castings	105
Goodrich, B. F., Co., The, Aviation Products Division	63
Goodyear Tire & Rubber Co., The, Industrial Products Division	2
Gray Tool Co.	192
Gries Reproducer Corporation	174
Groov-Pin Corporation	73
Haloid Xerox, Inc.	100, 200
Hamilton Foundry, Inc.	183
Hanna Engineering Works	87
Harrison Home Products Corporation	38
Heinz Electric Co.	166
Hercules Powder Co.	218
Hetherington Inc.	35
Hilliard Corporation, The	40
Hoffman Engineering Corporation	180
Hooker Chemical Corporation, Durez Plastics Division	51
Howard Industries, Inc.	78, 79
Hydraulic Unit Specialties Co.	208
Industrial Timer Corporation	160
Ingersoll-Rand	41
International Basic Economy Corporation, The Bellows Co. Division	77
International Harvester Co.	50
International Nickel Co., Inc., The	55
Invo Spline, Inc.	210
Jordan Corporation, OPW Division	215
Joy Manufacturing Co.	68
Koppers Co., Inc.	80
Lamb Electric Co., The	90
Lepel High Frequency Laboratories, Inc.	212
Link-Belt Co.	1
Lovely Flexible Coupling Co.	182
McGill Manufacturing Co., Inc., Bearing Division	88, 89
MacLean-Fogg Lock Nut Co.	187
Malleable Castings Council	70, 71
Marion Instrument Division, Minneapolis-Honeywell Regulator Co.	207
Marlin-Rockwell Corporation	173
Maxson, W. L., Corporation, The, Unimax Switch Division	207
Mayline Co., Inc.	216
M-D Blowers, Inc.	201
Micro Switch Division, Minneapolis-Honeywell Regulator Co.	31
Minneapolis-Honeywell Regulator Co., Marion Instrument Division	207
Minneapolis-Honeywell Regulator Co., Micro Switch Division	31
Minnesota Mining and Manufacturing Co.	60, 61
Moore, George W., Inc.	208
Morse Chain Co., A Borg-Warner Industry	67
Narda Hydraulics Corporation, The	172
New Departure, Division of General Motors Corporation	11
New Hampshire Ball Bearings, Inc.	48
Norgren, C. A., Co.	42, 43
Northern Ordnance, Inc.	198
Ohio Nut and Bolt Co., The	214
Ohmrite Manufacturing Co.	59
Oilgear Co., The	7
O'Neill-Irwin Mfg. Co.	166
Ortman-Miller Machine Co.	109

MACHINE DESIGN

Penton Building, Cleveland 13, Ohio
Main 1-8260

BUSINESS STAFF

ROBERT L. HARTFORD
Business Manager
MARY L. CALLAHAN
Advertising Service Manager
RICHARD A. TEMPLETON
Research and Circulation Manager
BARBARA O'LEARY
Staff Assistant
ROBERT E. LESSING
Production Manager

District Offices

New York 1760 East 42nd St.
RUSSELL H. SMITH, JAMES A. STANGARONE
Murray Hill 2-2581
Simsbury, Conn.17 Deerfield Lane
ALAN C. BUGBEE
Oldfield 8-4764
Rochester 7747 East Ave.
EDWARD F. CLANCY
Browning 1-2109
Dresher (Philadelphia), Pa.1335 Harris Rd.
CHANDLER C. HENLEY
Mitchell 4-2585
Cleveland 13Penton Bldg.
JACK W. WALTON, DON J. BILLINGS
Main 1-8260
Detroit 3515800 West McNichols Rd.
ARNOLD T. SUHART
Broadway 3-8150
Chicago 11520 North Michigan Ave.
HOWARD H. DREYER, ROBERT Z. CHEW
DONALD A. IVINS, CHARLES F. REINER
Whitehall 4-1234
Los Angeles 365943 West Colgate Ave.
F. J. FULLER
Webster 1-6865
San Francisco 457 Post St.
Robert W. Walker Co.
Sutter 1-5568
Griffin, Ga.112½ East Solomon St.
FRED J. ALLEN
Griffin 8-8681
Clearwater, Fla.1954 Jeffords Dr.
H. G. ROWLAND
(Clearwater) 31-4121
Dallas 35818 Exchange Bank Bldg.
JAMES H. CASH
Fleetwood 1-4523
London, S.W.12 Caxton St., Westminster

Published by
THE PENTON PUBLISHING COMPANY

G. O. HAYSChairman
R. C. JAENKEPresident
F. G. STEINEBACHVice President and Secy.
F. O. RICEVice President
J. P. LIPKATreasurer and Assistant Secretary

Also Publisher of
STEEL, FOUNDRY, NEW EQUIPMENT DIGEST, AUTOMATION

MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, \$10. Single copies \$1.00. Other countries: One year, \$25. Published every other Thursday and copyrighted 1959 by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.



backtalk—

—We Get a Long

Before joining the staff of MACHINE DESIGN, associate editor Melvin E. Long was equally at home driving a farm tractor or developing a new one. He is a graduate of the University of Illinois in mechanical engineering and also has a degree in agriculture from Ohio State. After earning the latter degree, he also learned about the practical side of farming and the equipment it requires by working on a 600-acre farm in Ohio. For the last four years, Mel



has applied his talents to new product development at the John Deere tractor plants in both Waterloo and Dubuque, Iowa. Going the gentlemen farmers one better, Mel is a "society" farmer—he belongs to the American Society of Agricultural Engineers. He is also a member of SAE.

Mel's know-how and his gift of and need for expression quite naturally led him to submit articles on farm machinery to various agricultural magazines. His articles were well accepted, and he did considerable free-lance writing during the time he was employed at John Deere. Previous writing experience came from "some work" on his college engineering magazine—enough work that he was made editor during his senior year.

Mel's present duties on his 0.007 acre of MACHINE DESIGN "land" include editing articles and writing "Noteworthy Patents."

—Between the Lines

In the last issue, this page included an item whose message was an appeal to engineers to use plain language. Talking back to ourselves, we hereby point out that some of the plain, everyday words that show up in correspond-

ence, for instance, can hide a multitude of misinformation. Here are definitions of some common words and phrases, exposed in the "Engineer's Lexicon," a little pamphlet furnished by the Auburn Manufacturing Co.

policy—we can hide behind this

program—any assignment that can't be completed by one telephone call

meeting—a mass mulling by master minds, where minutes are kept and hours are wasted

conference—a gathering where conversation is substituted for the dreariness of labor and the loneliness of thought

activate—make carbons and add more names to the memo

reliable source—the guy you just met

informed source—the guy who told the guy you just met

unimpeachable source—the guy who started the rumor originally

under active consideration—we are looking in the files for it

will advise in due course—if we ever figure it out, we'll let you know

—The Ubiquitous Formula

Mathematical formulas are part of the vernacular of engineering, of course, but this form of expression seems to be finding its way into more commercial language as well. The American Association of Highway Officials may adopt a new method of rating contractors who submit bids for road construction and, although a number of factors must be considered in awarding contracts for millions of dollars' worth of road work, the procedure has been reduced to a rather simple formula:

$$Q = CF + \frac{(R + L + E)F}{2} - U$$

where Q = qualification amount; C = working capital; F = assigned ability factor; R = unencumbered real estate value; L = letters of credit; E = book value of unencumbered equipment; U = value of uncompleted work.

—And One for the Road to Success

Another formula, credited to the genius of Albert Einstein, came to our attention recently. This one is for success: If A = success, then the formula is $A = X + Y + Z$. X is work; Y is play; and Z is keep your mouth shut.

Advertising Index

Paramount Die Casting Co.	212
Perfecting Service Co.	211
Pasco Products Division, Borg-Warner Corporation	49
Polymer Corporation of Pennsylvania, The ..	186
Post, Frederick, Co.	15
Potter & Brumfield, Division of American Machine & Foundry Co.	171

Rae Motor Corporation	212
Reeves Brothers, Inc., Vulcan Rubber Products Division	211
Reliance Electric and Engineering Co.	102, 103
Republic Steel Corporation	84, 85
Revere Copper and Brass, Inc.	69
Robbins & Myers, Inc.	94
Rockford Clutch Division, Borg-Warner Corporation	194
Ross Operating Valve Co.	56, 57
Russell, Burdall & Ward Bolt and Nut Co.	181

Sanders Associates, Inc., Flexprint Products Division	46, 47
Sandvik Steel, Inc.	208
Schrader's, A. Son, Division of Scovill Manufacturing Co.	98
Scovill Manufacturing Co., A. Schrader's Son Division	98
Servospeed, Division of Electro Devices, Inc.	192
Sigma Instruments, Inc.	189
South Chester Corporation, Southco Division ..	107
Southco Division, South Chester Corporation ..	107
Southwest Products Co.	207
Spaulding Fibre Co., Inc.	72
Stackpole Carbon Co.	178
Stacor Equipment Co.	200
Standard Screw Co.	169
Star Stainless Screw Co.	217
Sturtevant, P. A., Co.	215
Superior Tube Co.	58
Synchro-Start Products, Inc.	209

Texas Instruments, Inc., Metals & Controls Division	221
Thomson Industries, Inc.	185
Timken Roller Bearing Co., The, Steel and Tube Division	33
Tinnerman Products, Inc.	110
Torrington Co., The	13
Tube Reducing Corporation	52
Tubular Rivet & Stud Co.	37
Tuthill Pump Co.	222
Twin Disc Clutch Co.	9

Unimax Switch Division, The W. L. Maxson Corporation	207
United Electric Controls Co.	217
United States Rubber, Mechanical Goods Division	29
Universal Drafting Machine Corporation	206

Vascoloy-Ramet	106
Veeder-Roof, Inc.	104
Viking Pump Co.	174
Vulcan Rubber Products Division, Reeves Brothers, Inc.	211

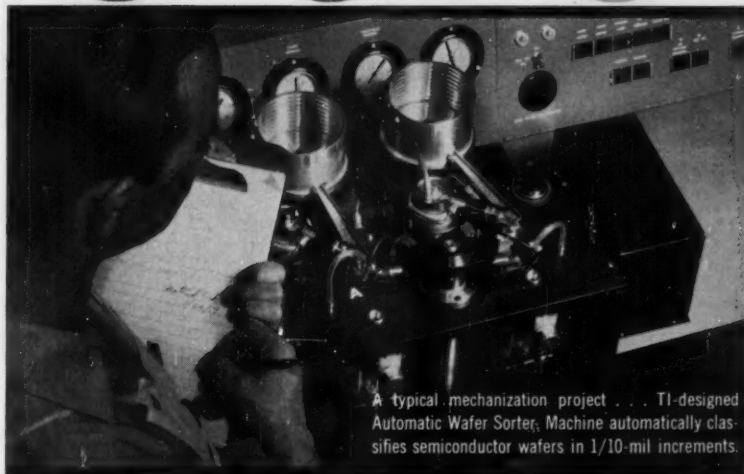
Wagner Electric Corporation	66
Washington Steel Corporation	196
Webster Electric, Oil Hydraulics Division	191
Weckesser Co.	210
White, S. S., Plastics Division	213
Winsmith, Inc.	203
Winzeler Manufacturing & Tool Co.	213
Wire Belt Company of America	209

Young Radiator Co.	197
-------------------------	-----

Zenith Electric Co.	202
--------------------------	-----

Engineers Available or Wanted	218
-------------------------------------	-----

CAREER
OPPORTUNITIES
AT TI



A typical mechanization project... TI-designed Automatic Wafer Sorter. Machine automatically classifies semiconductor wafers in 1/10-mil increments.

MECHANIZATION ENGINEER

your future: a challenging opportunity with an industry leader

Accelerate your professional growth by joining one of Texas Instruments most important operations...the mechanization of semiconductor manufacturing equipment!

Work with or lead a mechanization team of top talent with advanced facilities. Specific and rewarding assignments include the design and test of production and prototype equipment on a problem-solving basis, and you will materially contribute to TI's record of engineering and manufacturing achievements.

Advanced personnel policies include company-paid profit sharing (*over last several years, an average of more than 12% of base salary*)...and premium living is furnished by Dallas' climate and excellent neighborhoods, schools and shopping facilities.

These jobs require an engineering degree and at least three years' work in design of manufacturing equipment for precision components.

*Interviews will be held in your area soon.
Please send a resume immediately to:*

C. A. Besio, Dept. 203-MD

For
immediate
Eastern
appointment.
contact
W. T. Hudson
Dept. 203-E-MD
1141 E. Jersey St.
Elizabeth, N. J.

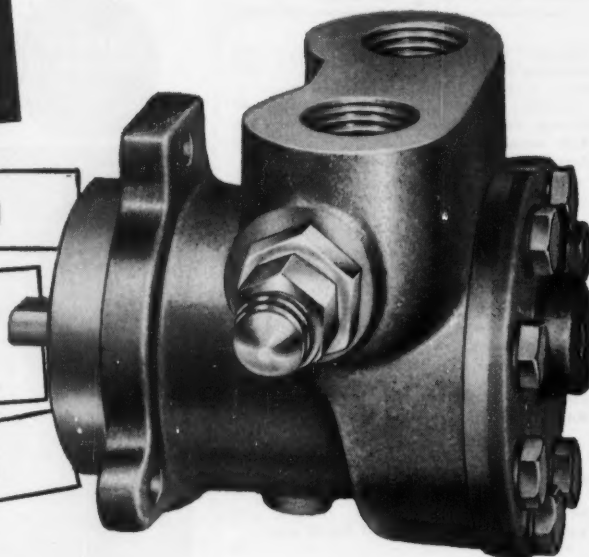
TEXAS  **INSTRUMENTS**
INCORPORATED
SEMICONDUCTOR - COMPONENTS DIVISION
POST OFFICE BOX 312 • DALLAS, TEXAS

NOW

Compact design

Complete mounting
interchangeability

Built-in relief valves



on TUTHILL small industrial pumps

Now a new design—Series LPFV—gives you even greater flexibility with Tuthill small industrial pumps . . . the industry standard for dependable operation for many years.

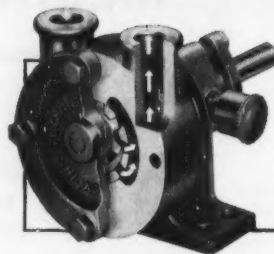
Complete interchangeability allows the use of any one of five different sizes in the series on the same mounting arrangement. Capacities range from 20 to 360 gallons per hour, at pressures up to 500 psi. Normally provided for 1800 RPM, 3600 RPM speeds are permissible in most cases. And a built-in relief valve is now offered as optional equipment on all LPF models.

Compactness, an outstanding characteristic of all Tuthill pumps, is particularly exemplified in the new model LPFV with its shorter mounting hub. It is also available in close coupled motor-pump combinations for applications where space and weight are at a premium.

The newly designed model LPFV incorporates the performance-tested operating characteristics of Tuthill's internal gear construction described at right. In thousands of applications . . . in hydraulics, lubricating, transfer, circulating and other services . . . Tuthill internal gear pumps have established enviable records for reliability and quiet operation.

Over 700 models of Tuthill internal gear pumps are available to provide one especially suited to your application. These include stripped models for built-in applications, cartridge pumps, reversible models . . . a host of specialized pumps for each individual service. Mail the coupon today.

Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities From 1 to 200 GPM; for Pressures to 1500 PSI; speeds to 3600 RPM.



**TUTHILL internal
gear pumping
principle**

In Tuthill internal gear pumps, proven in 30 years of operation, there are only two moving parts. The principle is based upon the use of a rotor, idler gear and a crescent shape partition cast integral with the cover. Power applied to the rotor is transmitted to the idler gear with which it meshes. The space between the outside diameter of the idler and the outside diameter of the rotor is sealed by the crescent. As the pump starts the teeth come out of mesh increasing the volume. This creates a partial vacuum drawing the liquid into the pump through the suction port. The liquid fills the spaces between the teeth of the idler and the rotor and is carried past the crescent partition to the pressure side of the pump. When the teeth mesh on the pressure side the liquid is forced from the spaces and out through the discharge port.

Tuthill Pump Company
953 East 95th Street
Chicago 19, Illinois

- ☐ Please forward information on LPF series
☐ Please have your representative call

Name _____ Title _____

Company _____

Address _____

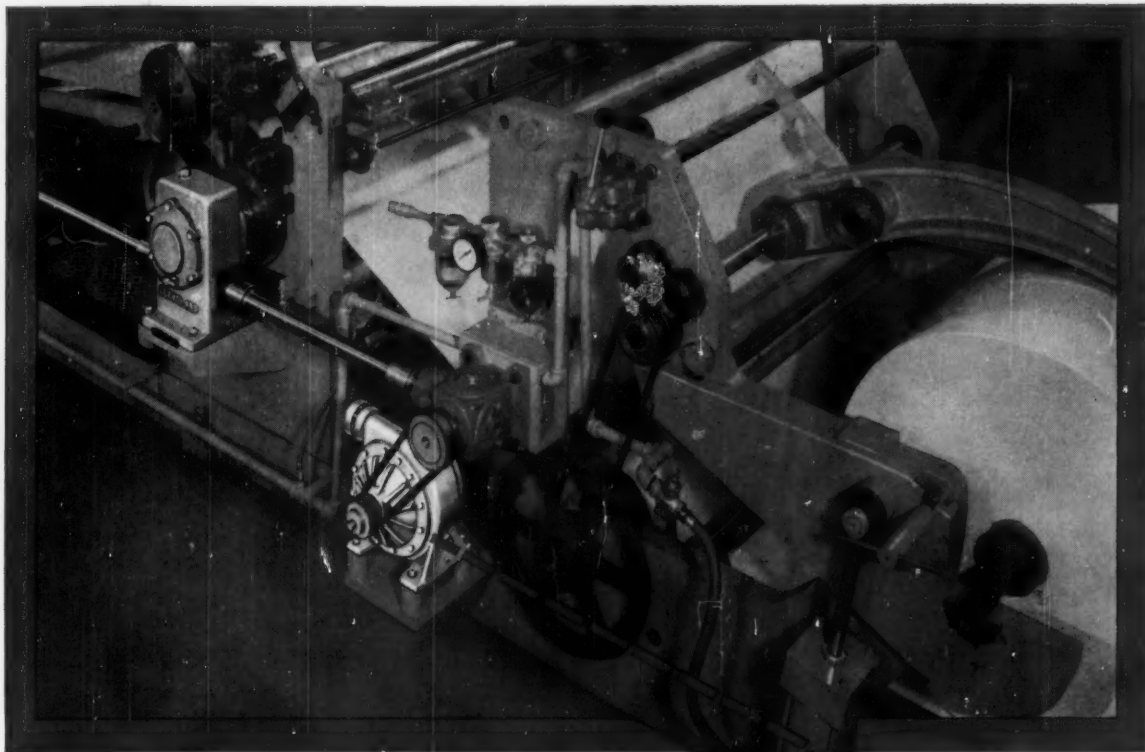
City _____ State _____



TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois





Cleveland Speed Variator accurately controls paper web fed into Schriber Printing Press

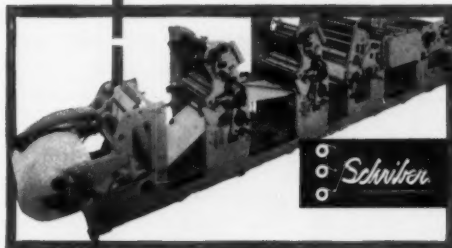
This new Rotary Offset Business Forms Press built by Schriber Press Company of Dayton, Ohio, was designed to provide printers with more hourly impressions—more daily output.

Its new infed web tension control drive gives absolute constant tension from mill roll through a Cleveland Speed Variator-driven metering cylinder to press.

The Variator compensates for paper thickness—maintains constant surface speed of paper to the press—guarantees finished printing will always stay "in register".

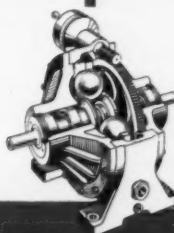
A modified Cleveland Speed Variator providing increased precision within a limited ($\pm 25\%$) range was selected for this important function. This was accomplished by changing the curve of Variator's iris plate. Thus, this Variator allows exacting adjustment for paper machine tension—holds that tension or can easily be changed to another speed setting.

If your operations demand speed variation, be sure to get the complete "Cleveland Speed Variator Story". It's all in free Bulletin K-200—write for your personal copy today.



HOW IT WORKS

Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts. Relative speeds of the shafts are adjusted by changing the positioning of the axles on which the balls rotate (see cutaway view, left).




The Cleveland Worm and Gear Company
Speed Variator Division
3287 East 80th Street, Cleveland 4, Ohio

A subsidiary of
Eaton Manufacturing Company



Sales Representatives in all major industrial markets
In Canada—Peacock Brothers Limited

CLEVELAND
SPEED VARIATOR



FOR ECONOMY
PERFORMANCE AND DEPENDABILITY

Standardize on Cutler-Hammer Three-Star Motor Control

★ **INSTALLS EASIER** The cost of installing motor control is almost always greater than the cost of the equipment, often two or three times as much. This is why Cutler-Hammer made "easier installation" a key objective in designing the Cutler-Hammer Three-Star Motor Control line. Its compact construction saves valuable panel area. Three-point keyhole mounting, straight-through wiring, sure-grip terminals, and color coded magnet coils save you time and effort on every job.

★ **WORKS BETTER** Better performance is more than a mere claim in the Cutler-Hammer Three-Star Motor Control line, it is a proven fact. Light weight, short stroke movable contacts hold the inertia effect to a bare minimum. Accurately calibrated overload relays are adjustable to within 3% of full load motor current, not 10% or 12% as others. Motors work up to full capacity without time-wasting nuisance tripping of the overload relay.

★ **LASTS LONGER** Repeated tests prove Cutler-Hammer Three-Star Motor Control provides substantially greater electrical and mechanical life. Vertical dust-safe contacts stay clean, free from the ravages of arcing and pitting caused by dust contamination. Magnet armatures pivot on smooth hardened steel bearing surfaces, avoid the uncertainties of sliding friction.

For maximum economy, performance and dependability; standardize on Cutler-Hammer Three-Star Motor Control. Write today for the Panelbuilders Handbook, the handy guide to control panel design. Address your request on your company letterhead. Ask for Publication EE120-A243. Cutler-Hammer Inc., Milwaukee 1, Wisconsin.



CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wis. • Division: Airborne Instruments Laboratory. • Subsidiary: Cutler-Hammer International, C. A.

Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation.

